

TI-83 Plus / TI-83 Plus Silver Edition

Graphing Calculator Guidebook

First Steps

- On/Off
- Menus
- Using parentheses
- Graphing a function
- Modes
- Lists

Creating...

- Tables
- Matrices
- Data and lists
- Split screen

Beyond the Basics

- Inferential statistics
- Programming
- Archiving/Unarchiving
- Menu maps

More Information

- Sending and receiving
- Formulas
- Troubleshooting
- Support and service



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Chapter 1: Operating the TI-83 Plus Silver Edition

Documentation Conventions

In the body of this guidebook, TI-83 Plus (in silver) refers to the TI-83 Plus Silver Edition. Sometimes, as in Chapter 19, the full name TI-83 Plus Silver Edition is used to distinguish it from the TI-83 Plus.

All the instructions and examples in this guidebook also work for the TI-83 Plus. All the functions of the TI-83 Plus Silver Edition and the TI-83 Plus are the same. The two calculators differ only in available RAM memory and Flash application ROM memory.

TI-83 Plus Keyboard

Generally, the keyboard is divided into these zones: graphing keys, editing keys, advanced function keys, and scientific calculator keys.

Keyboard Zones

Graphing — Graphing keys access the interactive graphing features.

Editing — Editing keys allow you to edit expressions and values.

Advanced — Advanced function keys display menus that access the advanced functions.

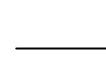
Scientific — Scientific calculator keys access the capabilities of a standard scientific calculator.

TI-83 Plus

Graphing Keys

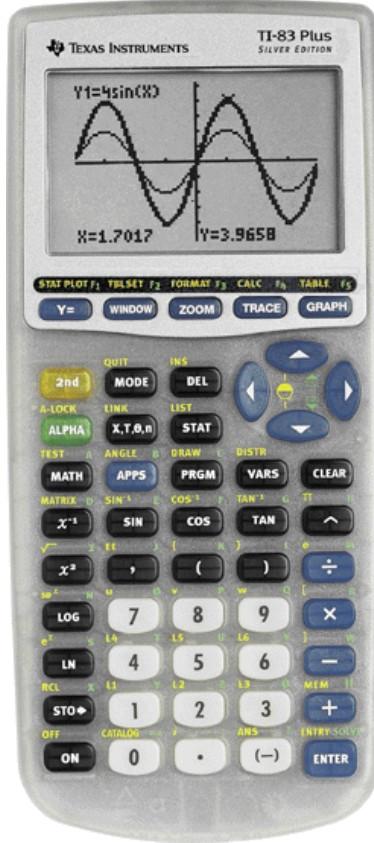
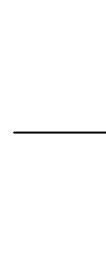


Editing Keys



Advanced Function Keys

Scientific Calculator Keys



Colors may vary in actual product.

Using the Color-Coded Keyboard

The keys on the TI-83 Plus are color-coded to help you easily locate the key you need.

The light gray keys are the number keys. The blue keys along the right side of the keyboard are the common math functions. The blue keys across the top set up and display graphs. The blue **[APPS]** key provides access to applications such as the Finance application.

The primary function of each key is printed on the keys. For example, when you press **[MATH]**, the **MATH** menu is displayed.

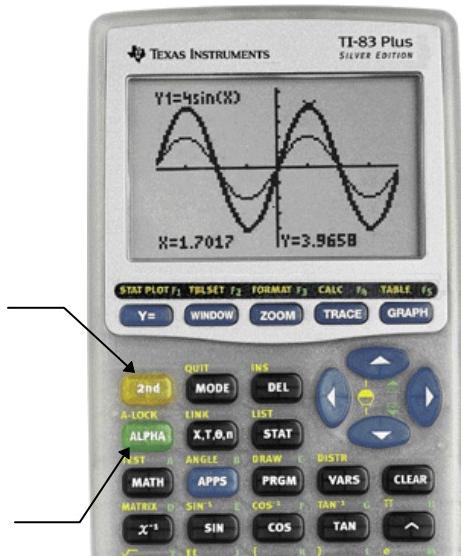
Using the **[2nd]** and **[ALPHA]** Keys

The secondary function of each key is printed in yellow above the key. When you press the yellow **[2nd]** key, the character, abbreviation, or word printed in yellow above the other keys becomes active for the next keystroke. For example, when you press **[2nd]** and then **[MATH]**, the **TEST** menu is displayed. This guidebook describes this keystroke combination as **[2nd] [TEST]**.

The alpha function of each key is printed in green above the key. When you press the green [ALPHA] key, the alpha character printed in green above the other keys becomes active for the next keystroke. For example, when you press [ALPHA] and then [MATH], the letter A is entered. This guidebook describes this keystroke combination as [ALPHA] [A].

The [2nd] key
accesses the
second function
printed in yellow
above each key.

The [ALPHA] key
accesses the alpha
function printed in
green above each
key.



Turning On and Turning Off the TI-83 Plus

Turning On the Calculator

To turn on the TI-83 Plus, press **[ON]**.

- If you previously had turned off the calculator by pressing **[2nd]** **[OFF]**, the TI-83 Plus displays the home screen as it was when you last used it and clears any error.
- If Automatic Power Down™ (APD™) had previously turned off the calculator, the TI-83 Plus will return exactly as you left it, including the display, cursor, and any error.
- If the TI-83 Plus is turned off and you connect it to another calculator or personal computer, the TI-83 Plus will “wake up” when you complete the connection.
- If the TI-83 Plus is turned off and connected to another calculator or personal computer, any communication activity will “wake up” the TI-83 Plus.



To prolong the life of the batteries, APD turns off the TI-83 Plus automatically after about five minutes without any activity.

Turning Off the Calculator

To turn off the TI-83 Plus manually, press **[2nd] [OFF]**.

- All settings and memory contents are retained by Constant Memory™.
- Any error condition is cleared.

Batteries

The TI-83 Plus uses four AAA alkaline batteries and has a user-replaceable backup lithium battery (CR1616 or CR1620). To replace batteries without losing any information stored in memory, follow the steps in Appendix B.

Setting the Display Contrast

Adjusting the Display Contrast

You can adjust the display contrast to suit your viewing angle and lighting conditions. As you change the contrast setting, a number from **0** (lightest) to **9** (darkest) in the top-right corner indicates the current level. You may not be able to see the number if contrast is too light or too dark.

Note: The TI-83 Plus has 40 contrast settings, so each number **0** through **9** represents four settings.

The TI-83 Plus retains the contrast setting in memory when it is turned off.

To adjust the contrast, follow these steps.

1. Press and release the **2nd** key.
2. Press and hold **▼** or **▲**, which are below and above the contrast symbol (yellow, half-shaded circle).
 - **▼** lightens the screen.
 - **▲** darkens the screen.

Note: If you adjust the contrast setting to **0**, the display may become completely blank. To restore the screen, press and release **[2nd]**, and then press and hold **[A]** until the display reappears.

When to Replace Batteries

When the batteries are low, a low-battery message is displayed when you:

- Turn on the calculator.
- Download a new application.
- Attempt to upgrade to new software.

To replace the batteries without losing any information in memory, follow the steps in Appendix B.

Generally, the calculator will continue to operate for one or two weeks after the low-battery message is first displayed. After this period, the TI-83 Plus will turn off automatically and the unit will not operate. Batteries must be replaced. All memory should be retained.

Note: The operating period following the first low-battery message could be longer than two weeks if you use the calculator infrequently.

The Display

Types of Displays

The TI-83 Plus displays both text and graphs. Chapter 3 describes graphs. Chapter 9 describes how the TI-83 Plus can display a horizontally or vertically split screen to show graphs and text simultaneously.

Home Screen

The home screen is the primary screen of the TI-83 Plus. On this screen, enter instructions to execute and expressions to evaluate. The answers are displayed on the same screen.

Displaying Entries and Answers

When text is displayed, the TI-83 Plus screen can display a maximum of 8 lines with a maximum of 16 characters per line. If all lines of the display are full, text scrolls off the top of the display. If an expression on the home screen, the $Y=$ editor (Chapter 3), or the program editor (Chapter 16) is longer than one line, it wraps to the beginning of the next line. In numeric editors such as the window screen (Chapter 3), a long expression scrolls to the right and left.

When an entry is executed on the home screen, the answer is displayed on the right side of the next line.

The TI-83 Plus screen displays the entry `log(2)` in the top left and its decimal approximation `.3010299957` in the bottom right. Two arrows point from the text "Entry" and "Answer" to the respective parts of the screen.

The mode settings control the way the TI-83 Plus interprets expressions and displays answers.

If an answer, such as a list or matrix, is too long to display entirely on one line, an ellipsis (...) is displayed to the right or left. Press \blacktriangleright and \blacktriangleleft to display the answer.

The TI-83 Plus screen displays the entry `L1` in the top left and its elements `{25.12 874.2 36...}` in the bottom right. Two arrows point from the text "Entry" and "Answer" to the respective parts of the screen.

Returning to the Home Screen

To return to the home screen from any other screen, press $[2nd]$ [QUIT].

Busy Indicator

When the TI-83 Plus is calculating or graphing, a vertical moving line is displayed as a busy indicator in the top-right corner of the screen. When you pause a graph or a program, the busy indicator becomes a vertical moving dotted line.

Display Cursors

In most cases, the appearance of the cursor indicates what will happen when you press the next key or select the next menu item to be pasted as a character.

| Cursor | Appearance | Effect of Next Keystroke |
|--------|---|--|
| Entry | Solid rectangle  | A character is entered at the cursor; any existing character is overwritten |
| Insert | Underline  | A character is inserted in front of the cursor location |
| Second | Reverse arrow  | A 2nd character (yellow on the keyboard) is entered or a 2nd operation is executed |
| Alpha | Reverse A  | An alpha character (green on the keyboard) is entered or SOLVE is executed |
| Full | Checkerboard rectangle  | No entry; the maximum characters are entered at a prompt or memory is full |

If you press **ALPHA** during an insertion, the cursor becomes an underlined **A (A)**. If you press **2nd** during an insertion, the underlined cursor becomes an underlined **↑ (↑)**.

Graphs and editors sometimes display additional cursors, which are described in other chapters.

Entering Expressions and Instructions

What Is an Expression?

An expression is a group of numbers, variables, functions and their arguments, or a combination of these elements. An expression evaluates to a single answer. On the TI-83 Plus, you enter an expression in the same order as you would write it on paper. For example, πR^2 is an expression.

You can use an expression on the home screen to calculate an answer. In most places where a value is required, you can use an expression to enter a value.

$(1/3)^2$
•1111111111

WINDOW
Xmin=-10
Xmax=2 π

Entering an Expression

To create an expression, you enter numbers, variables, and functions from the keyboard and menus. An expression is completed when you press [ENTER], regardless of the cursor location. The entire expression is evaluated according to Equation Operating System (EOS™) [rules](#), and the answer is displayed.

Most TI-83 Plus functions and operations are symbols comprising several characters. You must enter the symbol from the keyboard or a menu; do not spell it out. For example, to calculate the log of 45, you must press **LOG** 45. Do not enter the letters L, O, and G. If you enter **LOG**, the TI-83 Plus interprets the entry as implied multiplication of the variables L, O, and G.

Calculate $3.76 \div (-7.9 + \sqrt{5}) + 2 \log 45$.

3 **.** 76 **÷** (**(** **(-**) 7 **.** 9 **+** **2nd** [**√**] **5**)
5 **[** **]** **]** **+** 2 **LOG** 45 **[** **]** **ENTER** 3.76/(-7.9+√(5))
+2log(45)
2.642575252

Multiple Entries on a Line

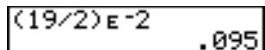
To enter two or more expressions or instructions on a line, separate them with colons (**ALPHA** [:]). All instructions are stored together in last entry (**ENTRY**).

5→A:2→B:A/B
2.5

Entering a Number in Scientific Notation

To enter a number in scientific notation, follow these steps.

1. Enter the part of the number that precedes the exponent. This value can be an expression.
2. Press [2nd] [EE]. E is pasted to the cursor location.
3. If the exponent is negative, press [-], and then enter the exponent, which can be one or two digits.



(19/2)E-2 .095

When you enter a number in scientific notation, the TI-83 Plus does not automatically display answers in scientific or engineering notation. The [mode settings](#) and the size of the number determine the display format.

Functions

A function returns a value. For example, \div , $-$, $+$, $\sqrt{}$, and \log are the functions in the example on the previous page. In general, the first letter of each function is lowercase on the TI-83 Plus. Most functions take at least one argument, as indicated by an open parenthesis () following the name. For example, \sin requires one argument, $\sin(\text{value})$.

Instructions

An instruction initiates an action. For example, **ClrDraw** is an instruction that clears any drawn elements from a graph. Instructions cannot be used in expressions. In general, the first letter of each instruction name is uppercase. Some instructions take more than one argument, as indicated by an open parenthesis () at the end of the name. For example, **Circle(** requires three arguments, **Circle(X,Y,radius)**.

Interrupting a Calculation

To interrupt a calculation or graph in progress, which is indicated by the busy indicator, press **ON**.

When you interrupt a calculation, a menu is displayed.

- To return to the home screen, select **1:Quit**.
- To go to the location of the interruption, select **2:Goto**.

When you interrupt a graph, a partial graph is displayed.

- To return to the home screen, press **CLEAR** or any nongraphing key.
- To restart graphing, press a graphing key or select a graphing instruction.

TI-83 Plus Edit Keys

| Keystrokes | Result |
|--|---|
| [] or []] | Moves the cursor within an expression; these keys repeat. |
| [] or []] | Moves the cursor from line to line within an expression that occupies more than one line; these keys repeat. On the top line of an expression on the home screen, [] moves the cursor to the beginning of the expression. On the bottom line of an expression on the home screen, [] moves the cursor to the end of the expression. |
| [2nd] []] | Moves the cursor to the beginning of an expression. |
| [2nd] []] | Moves the cursor to the end of an expression. |
| [ENTER] | Evaluates an expression or executes an instruction. |
| [CLEAR] | On a line with text on the home screen, clears the current line. On a blank line on the home screen, clears everything on the home screen. In an editor, clears the expression or value where the cursor is located; it does not store a zero. |
| [DEL] | Deletes a character at the cursor; this key repeats. |
| [2nd] [INS] | Changes the cursor to an underline (<u>_</u>); inserts characters in front of the underline cursor; to end insertion, press [2nd] [INS] or press [], [], [], or []] |

| Keystrokes | Result |
|----------------|--|
| [2nd] | Changes the cursor to ; the next keystroke performs a 2nd operation (an operation in yellow above a key and to the left); to cancel 2nd, press [2nd] again. |
| [ALPHA] | Changes the cursor to ; the next keystroke pastes an alpha character (a character in green above a key and to the right) or executes SOLVE (Chapters 10 and 11); to cancel [ALPHA], press [ALPHA] or press , , , or . |
| [2nd] [A-LOCK] | Changes the cursor to ; sets alpha-lock; subsequent keystrokes (on an alpha key) paste alpha characters; to cancel alpha-lock, press [ALPHA]. If you are prompted to enter a name such as for a group or a program, alpha-lock is set automatically. |
| [X,T,Θ,n] | Pastes an X in Func mode, a T in Par mode, a θ in Pol mode, or an n in Seq mode with one keystroke. |

Setting Modes

Checking Mode Settings

Mode settings control how the TI-83 Plus displays and interprets numbers and graphs. Mode settings are retained by the Constant Memory feature when the TI-83 Plus is turned off. All numbers, including elements of matrices and lists, are displayed according to the current mode settings.

To display the mode settings, press **MODE**. The current settings are highlighted. Defaults are highlighted below. The following pages describe the mode settings in detail.

| | | |
|------------|------------------------|---|
| Normal | Sci Eng | Numeric notation |
| Float | 0123456789 | Number of decimal places |
| Radian | Degree | Unit of angle measure |
| Func | Par Pol Seq | Type of graphing |
| Connected | Dot | Whether to connect graph points |
| Sequential | Simul | Whether to plot simultaneously |
| Real | a+bi re ^θ i | Real, rectangular complex, or polar complex |
| Full | Horiz G-T | Full screen, two split-screen modes |

Changing Mode Settings

To change mode settings, follow these steps.

1. Press $\boxed{\downarrow}$ or $\boxed{\uparrow}$ to move the cursor to the line of the setting that you want to change.
2. Press $\boxed{\rightarrow}$ or $\boxed{\leftarrow}$ to move the cursor to the setting you want.
3. Press $\boxed{\text{ENTER}}$.

Setting a Mode from a Program

You can set a mode from a program by entering the name of the mode as an instruction; for example, **Func** or **Float**. From a blank program command line, select the mode setting from the mode screen; the instruction is pasted to the cursor location.

```
PROGRAM: TEST
:Func■
```

Normal, Sci, Eng

Notation modes only affect the way an answer is displayed on the home screen. Numeric answers can be displayed with up to 10 digits and a two-digit exponent. You can enter a number in any format.

Normal notation mode is the usual way we express numbers, with digits to the left and right of the decimal, as in **12345.67**.

Sci (scientific) notation mode expresses numbers in two parts. The significant digits display with one digit to the left of the decimal. The appropriate power of 10 displays to the right of **E**, as in **1.234567E4**.

Eng (engineering) notation mode is similar to scientific notation. However, the number can have one, two, or three digits before the decimal; and the power-of-10 exponent is a multiple of three, as in **12.34567E3**.

Note: If you select **Normal** notation, but the answer cannot display in 10 digits (or the absolute value is less than .001), the **TI-83 Plus** expresses the answer in scientific notation.

Float, 0123456789

Float (floating) decimal mode displays up to 10 digits, plus the sign and decimal.

0123456789 (fixed) decimal mode specifies the number of digits (**0** through **9**) to display to the right of the decimal. Place the cursor on the desired number of decimal digits, and then press **[ENTER]**.

The decimal setting applies to **Normal**, **Sci**, and **Eng** notation modes.

The decimal setting applies to these numbers:

- An answer displayed on the home screen
- Coordinates on a graph (Chapters 3, 4, 5, and 6)
- The **Tangent(** **DRAW** instruction equation of the line, **x**, and **dy/dx** values (Chapter 8)
- Results of **CALCULATE** operations (Chapters 3, 4, 5, and 6)
- The regression equation stored after the execution of a regression model (Chapter 12)

Radian, Degree

Angle modes control how the TI-83 Plus interprets angle values in trigonometric functions and polar/rectangular conversions.

Radian mode interprets angle values as radians. Answers display in radians.

Degree mode interprets angle values as degrees. Answers display in degrees.

Func, Par, Pol, Seq

Graphing modes define the graphing parameters. Chapters 3, 4, 5, and 6 describe these modes in detail.

Func (function) graphing mode plots functions, where **Y** is a function of **X** (Chapter 3).

Par (parametric) graphing mode plots relations, where **X** and **Y** are functions of **T** (Chapter 4).

Pol (polar) graphing mode plots functions, where **r** is a function of **θ** (Chapter 5).

Seq (sequence) graphing mode plots sequences (Chapter 6).

Connected, Dot

Connected plotting mode draws a line connecting each point calculated for the selected functions.

Dot plotting mode plots only the calculated points of the selected functions.

Sequential, Simul

Sequential graphing-order mode evaluates and plots one function completely before the next function is evaluated and plotted.

Simul (simultaneous) graphing-order mode evaluates and plots all selected functions for a single value of **X** and then evaluates and plots them for the next value of **X**.

Note: Regardless of which graphing mode is selected, the TI-83 Plus will sequentially graph all stat plots before it graphs any functions.

Real, $a+bi$, $re^{\theta i}$

Real mode does not display complex results unless complex numbers are entered as input.

Two complex modes display complex results.

- **$a+bi$** (rectangular complex mode) displays complex numbers in the form $a+bi$.
- **$re^{\theta i}$** (polar complex mode) displays complex numbers in the form $re^{\theta i}$.

Full, Horiz, G-T

Full screen mode uses the entire screen to display a graph or edit screen.

Each split-screen mode displays two screens simultaneously.

- **Horiz** (horizontal) mode displays the current graph on the top half of the screen; it displays the home screen or an editor on the bottom half (Chapter 9).
- **G-T** (graph-table) mode displays the current graph on the left half of the screen; it displays the table screen on the right half (Chapter 9).

Using TI-83 Plus Variable Names

Variables and Defined Items

On the TI-83 Plus you can enter and use several types of data, including real and complex numbers, matrices, lists, functions, stat plots, graph databases, graph pictures, and strings.

The TI-83 Plus uses assigned names for variables and other items saved in memory. For lists, you also can create your own five-character names.

| Variable Type | Names |
|----------------------|--|
| Real numbers | A, B, ... , Z |
| Complex numbers | A, B, ... , Z |
| Matrices | [A], [B], [C], ... , [J] |
| Lists | L1, L2, L3, L4, L5, L6, and user-defined names |
| Functions | Y1, Y2, . . . , Y9, Y0 |
| Parametric equations | X1T and Y1T, . . . , X6T and Y6T |
| Polar functions | r1, r2, r3, r4, r5, r6 |
| Sequence functions | u, v, w |
| Stat plots | Plot1, Plot2, Plot3 |
| Graph databases | GDB1, GDB2, . . . , GDB9, GDB0 |

| Variable Type | Names |
|------------------|-------------------------------------|
| Graph pictures | Pic1, Pic2, ... , Pic9, Pic0 |
| Strings | Str1, Str2, ... , Str9, Str0 |
| Apps | Applications |
| AppVars | Application variables |
| Groups | Grouped variables |
| System variables | Xmin, Xmax , and others |

Notes about Variables

- You can create as many list names as memory will allow (Chapter 11).
- Programs have user-defined names and share memory with variables (Chapter 16).
- From the home screen or from a program, you can store to matrices (Chapter 10), lists (Chapter 11), strings (Chapter 15), system variables such as **Xmax** (Chapter 1), **TblStart** (Chapter 7), and all **Y=** functions (Chapters 3, 4, 5, and 6).
- From an editor, you can store to matrices, lists, and **Y=** functions (Chapter 3).
- From the home screen, a program, or an editor, you can store a value to a matrix element or a list element.

- You can use **DRAW STO** menu items to store and recall graph databases and pictures (Chapter 8).
- Although most variables can be archived, system variables including r , t , x , y , and θ cannot be archived (Chapter 18)
- **Apps** are independent applications which are stored in Flash ROM. **AppVars** is a variable holder used to store variables created by independent applications. You cannot edit or change variables in **AppVars** unless you do so through the application which created them.

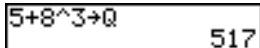
Storing Variable Values

Storing Values in a Variable

Values are stored to and recalled from memory using variable names. When an expression containing the name of a variable is evaluated, the value of the variable at that time is used.

To store a value to a variable from the home screen or a program using the **STO►** key, begin on a blank line and follow these steps.

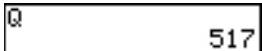
1. Enter the value you want to store. The value can be an expression.
2. Press **STO►**. → is copied to the cursor location.
3. Press **ALPHA** and then the letter of the variable to which you want to store the value.
4. Press **ENTER**. If you entered an expression, it is evaluated. The value is stored to the variable.



5+8³→Q 517

Displaying a Variable Value

To display the value of a variable, enter the name on a blank line on the home screen, and then press [ENTER].

A screenshot of a TI-Nspire CX CAS calculator's home screen. A single-line text input field is active, containing the number "517". The background of the screen is white.

Archiving Variables (Archive, Unarchive)

You can archive data, programs, or other variables in a section of memory called user data archive where they cannot be edited or deleted inadvertently. Archived variables are indicated by asterisks (*) to the left of the variable names. Archived variables cannot be edited or executed. They can only be seen and unarchived. For example, if you archive list L1, you will see that L1 exists in memory but if you select it and paste the name L1 to the home screen, you won't be able to see its contents or edit it until they are unarchived.

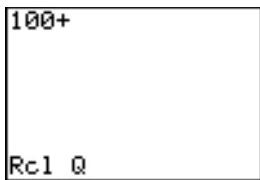
Recalling Variable Values

Using Recall (RCL)

To recall and copy variable contents to the current cursor location, follow these steps. To leave RCL, press **CLEAR**.

1. Press **2nd** [RCL]. **RCL** and the edit cursor are displayed on the bottom line of the screen.
2. Enter the name of the variable in any of five ways.
 - Press **ALPHA** and then the letter of the variable.
 - Press **2nd** [LIST], and then select the name of the list, or press **2nd** [L_n].
 - Press **2nd** [MATRIX], and then select the name of the matrix.
 - Press **VARS** to display the **VARS** menu or **VARS** **►** to display the **VARS Y-VARS** menu; then select the type and then the name of the variable or function.
 - Press **PRGM** **◀**, and then select the name of the program (in the program editor only).

The variable name you selected is displayed on the bottom line and the cursor disappears.



100+

Rcl 0

3. Press **[ENTER]**. The variable contents are inserted where the cursor was located before you began these steps.



100+517

Note: You can edit the characters pasted to the expression without affecting the value in memory.

ENTRY (Last Entry) Storage Area

Using ENTRY (Last Entry)

When you press [ENTER] on the home screen to evaluate an expression or execute an instruction, the expression or instruction is placed in a storage area called **ENTRY** (last entry). When you turn off the TI-83 Plus, **ENTRY** is retained in memory.

To recall **ENTRY**, press [2nd] [ENTRY]. The last entry is pasted to the current cursor location, where you can edit and execute it. On the home screen or in an editor, the current line is cleared and the last entry is pasted to the line.

Because the TI-83 Plus updates **ENTRY** only when you press [ENTER], you can recall the previous entry even if you have begun to enter the next expression.

| | | | | | | |
|---------|---------|---|--|-----|---|----|
| 5 | [+] | 7 | | 5+7 | | 12 |
| [ENTER] | | | | 5+7 | ■ | |
| [2nd] | [ENTRY] | | | | | |

Accessing a Previous Entry

The TI-83 Plus retains as many previous entries as possible in **ENTRY**, up to a capacity of 128 bytes. To scroll those entries, press **[2nd] [ENTRY]** repeatedly. If a single entry is more than 128 bytes, it is retained for **ENTRY**, but it cannot be placed in the **ENTRY** storage area.

1 **[STO►] [ALPHA] A**
[ENTER]
2 **[STO►] [ALPHA] B**
[ENTER]
[2nd] [ENTRY]

| | |
|-----|---|
| 1→A | 1 |
| 2→B | 2 |
| 2→B | ■ |

If you press **[2nd] [ENTRY]** after displaying the oldest stored entry, the newest stored entry is displayed again, then the next-newest entry, and so on.

[2nd] [ENTRY]

| | |
|-----|---|
| 1→A | 1 |
| 2→B | 2 |
| 1→A | ■ |

Reexecuting the Previous Entry

After you have pasted the last entry to the home screen and edited it (if you chose to edit it), you can execute the entry. To execute the last entry, press **[ENTER]**.

To reexecute the displayed entry, press [ENTER] again. Each reexecution displays an answer on the right side of the next line; the entry itself is not redisplayed.

0 [STO \blacktriangleright] [ALPHA] N

[ENTER]

[ALPHA] N + 1 [STO \blacktriangleright] [ALPHA] N [ALPHA]
[:] [ALPHA] N x^2 [ENTER]

[ENTER]

[ENTER]

| | |
|-------------------|---|
| 0+N | 0 |
| N+1+N:N \approx | 1 |
| | 9 |

Multiple Entry Values on a Line

To store to ENTRY two or more expressions or instructions, separate each expression or instruction with a colon, then press [ENTER]. All expressions and instructions separated by colons are stored in ENTRY.

When you press [2nd] [ENTRY], all the expressions and instructions separated by colons are pasted to the current cursor location. You can edit any of the entries, and then execute all of them when you press [ENTER].

For the equation $A=\pi r^2$, use trial and error to find the radius of a circle that covers 200 square centimeters. Use 8 as your first guess.

8 [STO►] [ALPHA] R [ALPHA] [:] [2nd] [π]
[ALPHA] R [x^2] [ENTER] [2nd] [ENTRY]

[2nd] [\blacktriangleleft] 7 [2nd] [INS] \square 95
[ENTER]

8 \rightarrow R: π R 2
201.0619298
8 \rightarrow R: π R 2
8 \rightarrow R: π R 2
201.0619298
7.95 \rightarrow R: π R 2
198.5565097

Continue until the answer is as accurate as you want.

Clearing ENTRY

Clear Entries (Chapter 18) clears all data that the TI-83 Plus is holding in the **ENTRY** storage area.

Using Ans in an Expression

When an expression is evaluated successfully from the home screen or from a program, the TI-83 Plus stores the answer to a storage area called **Ans** (last answer). **Ans** may be a real or complex number, a list, a matrix, or a string. When you turn off the TI-83 Plus, the value in **Ans** is retained in memory.

You can use the variable **Ans** to represent the last answer in most places. Press **2nd [ANS]** to copy the variable name **Ans** to the cursor location. When the expression is evaluated, the TI-83 Plus uses the value of **Ans** in the calculation.

Calculate the area of a garden plot 1.7 meters by 4.2 meters. Then calculate the yield per square meter if the plot produces a total of 147 tomatoes.

1 **[.** **7** **[X]** **4** **[.]** **2**

[ENTER]

147 **[÷]** **2nd [ANS]**

[ENTER]

1.7*4.2

7.14

147/Ans

20.58823529

Continuing an Expression

You can use **Ans** as the first entry in the next expression without entering the value again or pressing **2nd [ANS]**. On a blank line on the home screen, enter the function. The TI-83 Plus pastes the variable name **Ans** to the screen, then the function.

5 **[÷]** **2**

[ENTER]

[X] **9** **[.]** **9**

[ENTER]

5/2

2.5

Ans*9.9

24.75

Storing Answers

To store an answer, store **Ans** to a variable before you evaluate another expression.

Calculate the area of a circle of radius 5 meters. Next, calculate the volume of a cylinder of radius 5 meters and height 3.3 meters, and then store the result in the variable **V**.

```
2nd [π] 5 x2
ENTER
× 3 . 3
ENTER
STO ALPHA V
ENTER
```

| | |
|-----------------|-------------|
| π5 ² | 78.53981634 |
| Ans×3.3 | 259.1813939 |
| Ans→V | 259.1813939 |

TI-83 Plus Menus

Using a TI-83 Plus Menu

You can access most TI-83 Plus operations using menus. When you press a key or key combination to display a menu, one or more menu names appear on the top line of the screen.

- The menu name on the left side of the top line is highlighted. Up to seven items in that menu are displayed, beginning with item 1, which also is highlighted.
- A number or letter identifies each menu item's place in the menu. The order is 1 through 9, then 0, then A, B, C, and so on. The **LIST NAMES**, **PRGM EXEC**, and **PRGM EDIT** menus only label items 1 through 9 and 0.
- When the menu continues beyond the displayed items, a down arrow (↓) replaces the colon next to the last displayed item.
- When a menu item ends in an ellipsis (...), the item displays a secondary menu or editor when you select it.
- When an asterisk (*) appears to the left of a menu item, that item is stored in user data archive (Chapter 18).

| | |
|----------|--------|
| RAM FREE | 22494 |
| ARC FREE | 851076 |
| Pic1 | 767 |
| *Pic2 | 767 |
| L1 | 12 |

To display any other menu listed on the top line, press \blacktriangleright or \blacktriangleleft until that menu name is highlighted. The cursor location within the initial menu is irrelevant. The menu is displayed with the cursor on the first item.

Note: The Menu Map in Appendix A shows each menu, each operation under each menu, and the key or key combination you press to display each menu.

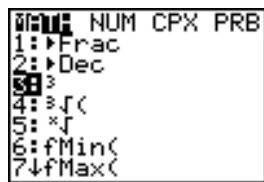
Displaying a Menu

While using your TI-83 Plus, you often will need to access items from its menus.

When you press a key that displays a menu, that menu temporarily replaces the screen where you are working. For example, when you press **MATH**, the **MATH** menu is displayed as a full screen.



After you select an item from a menu, the screen where you are working usually is displayed again.



Moving from One Menu to Another

Some keys access more than one menu. When you press such a key, the names of all accessible menus are displayed on the top line. When you highlight a menu name, the items in that menu are displayed. Press \blacktriangleright and \blacktriangleleft to highlight each menu name.



Scrolling a Menu

To scroll down the menu items, press \blacktriangledown . To scroll up the menu items, press \blacktriangleup .

To page down six menu items at a time, press [ALPHA] \blacktriangledown . To page up six menu items at a time, press [ALPHA] \blacktriangleup . The green arrows on the calculator, between \blacktriangledown and \blacktriangleup , are the page-down and page-up symbols.

To wrap to the last menu item directly from the first menu item, press \blacktriangleup . To wrap to the first menu item directly from the last menu item, press \blacktriangledown .

Selecting an Item from a Menu

You can select an item from a menu in either of two ways.

- Press the number or letter of the item you want to select. The cursor can be anywhere on the menu, and the item you select need not be displayed on the screen.

MATH  CPX PRB
 1:abs()
 2:round()
 3:iPart()
 4:fPart()
 5:int()
 6:min()
 7:max()

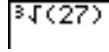
- Press  or  to move the cursor to the item you want, and then press **ENTER**.

After you select an item from a menu, the TI-83 Plus typically displays the previous screen.

MATH  CPX PRB
 3:iPart()
 4:fPart()
 5:int()
 6:min()
 7:max()
 8:lcm()
 9:gcd()

Note: On the **LIST NAMES**, **PRGM EXEC**, and **PRGM EDIT** menus, only items **1** through **9** and **0** are labeled in such a way that you can select them by pressing the appropriate number key. To move the cursor to the first item beginning with any alpha character or θ , press the key combination for that alpha character or θ . If no items begin with that character, the cursor moves beyond it to the next item.

Calculate $3\sqrt{27}$.

MATH    **ENTER**  3
27  **ENTER**

Leaving a Menu without Making a Selection

You can leave a menu without making a selection in any of four ways.

- Press **[2nd] [QUIT]** to return to the home screen.
- Press **[CLEAR]** to return to the previous screen.
- Press a key or key combination for a different menu, such as **[MATH]** or **[2nd] [LIST]**.
- Press a key or key combination for a different screen, such as **[Y=]** or **[2nd] [TABLE]**.

VARS and VARS Y-VARS Menus

VARS Menu

You can enter the names of functions and system variables in an expression or store to them directly.

To display the **VARS** menu, press **[VARS]**. All **VARS** menu items display secondary menus, which show the names of the system variables.

1:Window, **2:Zoom**, and **5:Statistics** each access more than one secondary menu.

| VARS Y-VARS | |
|------------------|--|
| 1: Window... | X/Y, T/ θ , and U/V/W variables |
| 2: Zoom... | ZX/ZY, ZT/Z θ , and ZU variables |
| 3: GDB... | Graph database variables |
| 4: Picture... | Picture variables |
| 5: Statistics... | XY, Σ , EQ, TEST, and PTS variables |
| 6: Table... | TABLE variables |
| 7: String... | String variables |

Selecting a Variable from the VARS Menu or VARS Y-VARS Menu

To display the **VARS Y-VARS** menu, press **VARS** **►**. **1:Function**, **2:Parametric**, and **3:Polar** display secondary menus of the **Y=** function variables.

| | |
|------------------|---|
| VARS | Y-VARS |
| 1: Function... | Y_n functions |
| 2: Parametric... | X_{nT}, Y_{nT} functions |
| 3: Polar... | r_n functions |
| 4: On/Off... | Lets you select/deselect functions |

Note: The sequence variables (**u**, **v**, **w**) are located on the keyboard as the second functions of **[7]**, **[8]**, and **[9]**.

To select a variable from the **VARS** or **VARS Y-VARS** menu, follow these steps.

1. Display the **VARS** or **VARS Y-VARS** menu.
 - Press **VARS** to display the **VARS** menu.
 - Press **VARS** **►** to display the **VARS Y-VARS** menu.
2. Select the type of variable, such as **2:Zoom** from the **VARS** menu or **3:Polar** from the **VARS Y-VARS** menu. A secondary menu is displayed.

3. If you selected **1:Window**, **2:Zoom**, or **5:Statistics** from the **VARS** menu, you can press **►** or **◀** to display other secondary menus.
4. Select a variable name from the menu. It is pasted to the cursor location.

Equation Operating System (EOS)

Order of Evaluation

The Equation Operating System (EOS) defines the order in which functions in expressions are entered and evaluated on the TI-83 Plus. EOS lets you enter numbers and functions in a simple, straightforward sequence.

EOS evaluates the functions in an expression in this order.

| Order Number | Function |
|--------------|--|
| 1 | Functions that precede the argument, such as $\sqrt{}$ (, sin (, or log (|
| 2 | Functions that are entered after the argument, such as 2^{\square} , ${}^{-1}$, ${}^{!}$, ${}^{\circ}$, ${}^{\prime}$, and conversions |
| 3 | Powers and roots, such as 2^5 or $5\sqrt{32}$ |
| 4 | Permutations (nPr) and combinations (nCr) |
| 5 | Multiplication, implied multiplication, and division |
| 6 | Addition and subtraction |
| 7 | Relational functions, such as $>$ or \leq |
| 8 | Logic operator and |
| 9 | Logic operators or and xor |

Note: Within a priority level, EOS evaluates functions from left to right. Calculations within parentheses are evaluated first.

Implied Multiplication

The TI-83 Plus recognizes implied multiplication, so you need not press \times to express multiplication in all cases. For example, the TI-83 Plus interprets 2π , $4\sin(46)$, $5(1+2)$, and $(2*5)7$ as implied multiplication.

Note: TI-83 Plus implied multiplication rules, although like the TI-83, differ from those of the TI-82. For example, the TI-83 Plus evaluates $1/2X$ as $(1/2)*X$, while the TI-82 evaluates $1/2X$ as $1/(2*X)$ (Chapter 2).

Parentheses

All calculations inside a pair of parentheses are completed first. For example, in the expression $4(1+2)$, EOS first evaluates the portion inside the parentheses, $1+2$, and then multiplies the answer, 3, by 4.

| | |
|----------|----|
| $4*1+2$ | 6 |
| $4(1+2)$ | 12 |

You can omit the close parenthesis () at the end of an expression. All open parenthetical elements are closed automatically at the end of an expression. This is also true for open parenthetical elements that precede the store or display-conversion instructions.

Note: An open parenthesis following a list name, matrix name, or Y= function name does not indicate implied multiplication. It specifies elements in the list (Chapter 11) or matrix (Chapter 10) and specifies a value for which to solve the Y= function.

Negation

To enter a negative number, use the negation key. Press $\boxed{(-)}$ and then enter the number. On the TI-83 Plus, negation is in the third level in the EOS hierarchy. Functions in the first level, such as squaring, are evaluated before negation.

For example, $-X^2$, evaluates to a negative number (or 0). Use parentheses to square a negative number.

$$\begin{array}{r} -2^2 \\ (-2)^2 \end{array} \quad \begin{array}{r} -4 \\ 4 \end{array}$$

$$\begin{array}{r} 2 \rightarrow A \\ -A^2 \\ (-A)^2 \end{array} \quad \begin{array}{r} 2 \\ -4 \\ 4 \end{array}$$

Note: Use the $\boxed{-}$ key for subtraction and the $\boxed{(-)}$ key for negation. If you press $\boxed{-}$ to enter a negative number, as in $9 \times \boxed{-} 7$, or if you press $\boxed{(-)}$ to indicate subtraction, as in $9 \boxed{(-)} 7$, an error occurs. If you press $\text{ALPHA A } \boxed{(-)} \text{ ALPHA B}$, it is interpreted as implied multiplication ($A * -B$).

Special Features of the TI-83 Plus

Flash – Electronic Upgradability



The TI-83 Plus uses Flash technology, which lets you upgrade to future software versions without buying a new calculator.

For details, refer to:
Chapter 19

As new functionality becomes available, you can electronically upgrade your TI-83 Plus from the Internet. Future software versions include maintenance upgrades that will be released free of charge, as well as new applications and major software upgrades that will be available for purchase from the TI web site: education.ti.com

1.56 Megabytes (M) of Available Memory

1.56 M of available memory are built into the TI-83 Plus. About 24 kilobytes (K) of RAM (random access memory) are available for you to compute and store functions, programs, and data.

For details, refer to:
Chapter 18

About 1.54 M of user data archive allow you to store data, programs, applications, or any other variables to a safe location where they cannot

be edited or deleted inadvertently. You can also free up RAM by archiving variables to user data

Applications

Applications can be installed to customize the TI-83 Plus to your classroom needs. The big 1.54 M archive space lets you store up to 94 applications at one time. Applications can also be stored on a computer for later use or linked unit-to-unit.

For details, refer to:
Chapter 18

Archiving

You can store variables in the TI-83 Plus user data archive, a protected area of memory separate from RAM. The user data archive lets you:

- Store data, programs, applications or any other variables to a safe location where they cannot be edited or deleted inadvertently.
- Create additional free RAM by archiving variables.

For details, refer to:
Chapter 18

By archiving variables that do not need to be edited frequently, you can free up RAM for applications that may require additional memory.

Calculator-Based Laboratory™ (CBL 2™, CBL™) and Calculator-Based Ranger™ (CBR™)

The TI-83 Plus comes with the CBL/CBR application already installed. When coupled with the (optional) CBL 2/CBL or CBR accessories, you can use the TI-83 Plus to analyze real world data.

For details, refer to:
Chapter 14

CBL 2/CBL and CBR let you explore mathematical and scientific relationships among distance, velocity, acceleration, and time using data collected from activities you perform.

CBL 2/CBL and CBR differ in that CBL 2/CBL allows you to collect data using several different probes analyzing temperature, light, voltage, or sonic (motion) data. CBR collects data using a built-in Sonic probe. CBL 2/CBL and CBR accessories can be linked together to collect more than one type of data at the same time. You can find more information on [CBL 2/CBL and CBR](#) in their user manuals.

Other TI-83 Plus Features

Getting Started has introduced you to basic TI-83 Plus operations. This guidebook covers the other features and capabilities of the TI-83 Plus in greater detail.

Graphing

You can store, graph, and analyze up to 10 functions, up to six parametric functions, up to six polar functions, and up to three sequences. You can use **DRAW** instructions to annotate graphs.

The graphing chapters appear in this order: **Function**, **Parametric**, **Polar**, **Sequence**, and **DRAW**.

**For graphing details,
refer to:**
Chapters 3, 4, 5, 6, 8

Sequences

You can generate sequences and graph them over time. Or, you can graph them as web plots or as phase plots.

For details, refer to:
Chapter 6

Tables

You can create function evaluation tables to analyze many functions simultaneously.

For details, refer to:
Chapter 7

Split Screen

You can split the screen horizontally to display both a graph and a related editor (such as the $Y=$ editor), the table, the stat list editor, or the home screen. Also, you can split the screen vertically to display a graph and its table simultaneously.

For details, refer to:
Chapter 9

Matrices

You can enter and save up to 10 matrices and perform standard matrix operations on them.

For details, refer to:
Chapter 10

Lists

You can enter and save as many lists as memory allows for use in statistical analyses. You can attach formulas to lists for automatic computation. You can use lists to evaluate expressions at multiple values simultaneously and to graph a family of curves.

For details, refer to:
Chapter 11

Statistics

You can perform one- and two-variable, list-based statistical analyses, including logistic and sine regression analysis. You can plot the data as a histogram, xyLine, scatter plot, modified or regular box-and-whisker plot, or normal probability plot. You can define and store up to three stat plot definitions.

For details, refer to:
Chapter 12

Inferential Statistics

You can perform 16 hypothesis tests and confidence intervals and 15 distribution functions. You can display hypothesis test results graphically or numerically.

For details, refer to:
Chapter 13

Applications

You can use such applications as Finance or the CBL/CBR. With the Finance application you can use time-value-of-money (**TVM**) functions to analyze financial instruments such as annuities, loans, mortgages, leases, and savings. You can analyze the value of money over equal time periods using cash flow functions. You can amortize loans with the amortization functions. With the CBL/CBR applications and CBL 2/CBL or CBR (optional) accessories, you can use a variety of probes to collect real world data.

For details, refer to:
Chapter 14

Your TI-83 Plus includes Flash applications in addition to the ones mentioned above. Press **[APPS]** to see the complete list of applications that came with your calculator.

Documentation for TI Flash applications is on the TI Resource CD. Visit education.ti.com/calc/guides for additional Flash application guidebooks.

CATALOG

The **CATALOG** is a convenient, alphabetical list of all functions and instructions on the TI-83 Plus. You can paste any function or instruction from the **CATALOG** to the current cursor location.

For details, refer to:
Chapter 15

Programming

You can enter and store programs that include extensive control and input/output instructions.

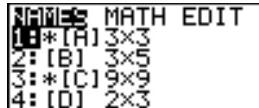
For details, refer to:
Chapter 16

Archiving

Archiving allows you to store data, programs, or other variables to user data archive where they cannot be edited or deleted inadvertently.

Archiving also allows you to free up RAM for variables that may require additional memory.

Archived variables are indicated by asterisks (*) to the left of the variable names.



Communication Link

The TI-83 Plus has a port to connect and communicate with another TI-83 Plus, a TI-83 Plus, a TI-83, a TI-82, a TI-73, CBL 2/CBL, or a CBR System.

For details, refer to:
Chapter 19

With the **TI™ Connect** or **TI-GRAFH LINK™** software and a **TI-GRAFH LINK** cable, you can also link the TI-83 Plus to a personal computer.

As future software upgrades become available on the TI web site, you can download the software to your PC and then use the **TI Connect** or **TI-GRAFH LINK** software and a **TI-GRAFH LINK** cable to upgrade your TI-83 Plus.

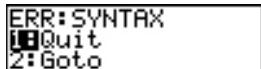
Error Conditions

Diagnosing an Error

The TI-83 Plus detects errors while performing these tasks.

- Evaluating an expression
- Executing an instruction
- Plotting a graph
- Storing a value

When the TI-83 Plus detects an error, it returns an error message as a menu title, such as **ERR:SYNTAX** or **ERR:DOMAIN**. Appendix B describes each error type and possible reasons for the error.



- If you select **1:Quit** (or press **2nd [QUIT]** or **[CLEAR]**), then the home screen is displayed.
- If you select **2:Goto**, then the previous screen is displayed with the cursor at or near the error location.

Note: If a syntax error occurs in the contents of a **Y=** function during program execution, then the **Goto** option returns to the **Y=** editor, not to the program.

Correcting an Error

To correct an error, follow these steps.

1. Note the error type (**ERR**:*error type*).
2. Select **2:Goto**, if it is available. The previous screen is displayed with the cursor at or near the error location.
3. Determine the error. If you cannot recognize the error, refer to Appendix B.
4. Correct the expression.

Chapter 2: **Math, Angle, and Test Operations**

Getting Started: Coin Flip

Getting Started is a fast-paced introduction. Read the chapter for details.

Suppose you want to model flipping a fair coin 10 times. You want to track how many of those 10 coin flips result in heads. You want to perform this simulation 40 times. With a fair coin, the probability of a coin flip resulting in heads is 0.5 and the probability of a coin flip resulting in tails is 0.5.

1. Begin on the home screen. Press **MATH** **▼** to display the **MATH PRB** menu. Press **7** to select **7:randBin(** (random Binomial). **randBin(** is pasted to the home screen. Press **10** to enter the number of coin flips. Press **,**. Press **.** **5** to enter the probability of heads. Press **,**. Press **40** to enter the number of simulations. Press **)**.

```
randBin(10,.5,40  
)
```

2. Press **ENTER** to evaluate the expression. A list of 40 elements is generated with the first 7 displayed. The list contains the count of heads resulting from each set of 10 coin flips. The list has 40 elements because this simulation was performed 40 times. In this example, the coin came up heads five times in the first set of 10 coin flips, five times in the second set of 10 coin flips, and so on.

```
randBin(10,.5,40)
(5 5 7 4 6 6 3 ...
```

3. Press **▶** or **◀** to view the additional counts in the list. Ellipses (...) indicate that the list continues beyond the screen.
4. Press **STO▶ [2nd] [L1]** **ENTER** to store the data to the list name **L1**. You then can use the data for another activity, such as plotting a histogram (Chapter 12).

```
randBin(10,.5,40)
(5 5 7 4 6 6 3 ...
Ans→L1
(5 5 7 4 6 6 3 ...
```

Note: Since **randBin(** generates random numbers, your list elements may differ from those in the example.

```
randBin(10,.5,40)
(5 5 7 4 6 6 3 ...
Ans→L1
...2 5 3 6 5 7 5 ...
```

Keyboard Math Operations

Using Lists with Math Operations

Math operations that are valid for lists return a list calculated element by element. If you use two lists in the same expression, they must be the same length.

$$\boxed{(1, 2) + (3, 4) + 5} \\ \boxed{(9, 11)}$$

+ (Addition), - (Subtraction), * (Multiplication), / (Division)

You can use + (addition, +), - (subtraction, -), * (multiplication, \times), and / (division, \div) with real and complex numbers, expressions, lists, and matrices. You cannot use / with matrices.

valueA + *valueB* *valueA* - *valueB*

valueA * *valueB* *valueA* / *valueB*

Trigonometric Functions

You can use the trigonometric (trig) functions (sine, SIN ; cosine, COS ; and tangent, TAN) with real numbers, expressions, and lists. The current angle mode setting affects interpretation. For example, $\text{sin}(30)$ in Radian mode returns $-.9880316241$; in Degree mode it returns $.5$.

sin(value)

cos(value)

tan(value)

You can use the inverse trig functions (arcsine, **[2nd] [SIN⁻¹]**; arccosine, **[2nd] [COS⁻¹]**; and arctangent, **[2nd] [TAN⁻¹]**) with real numbers, expressions, and lists. The current angle mode setting affects interpretation.

sin⁻¹(value)

cos⁻¹(value)

tan⁻¹(value)

Note: The trig functions do not operate on complex numbers.

^ (Power), ² (Square), $\sqrt{}$ (Square Root)

You can use **^** (power, **[^A]**), **²** (square, **[x^2]**), and **$\sqrt{}$** (square root, **[2nd] [$\sqrt{}$]**) with real and complex numbers, expressions, lists, and matrices. You cannot use **$\sqrt{}$** with matrices.

value^{power}

value²

\sqrt{value}

⁻¹ (Inverse)

You can use **⁻¹** (inverse, **[x^{-1}]**) with real and complex numbers, expressions, lists, and matrices. The multiplicative inverse is equivalent to the reciprocal, $1/x$.

value⁻¹

5⁻¹
.2

log(, 10^(, ln(

You can use **log(** (logarithm, **LOG**), **10^(** (power of 10, **2nd** [10^x]), and **ln(** (natural log, **LN**) with real or complex numbers, expressions, and lists.

log(value)

10^(power)

ln(value)

e^((Exponential)

e^((exponential, **2nd** [e^x]) returns the constant **e** raised to a power. You can use **e^(** with real or complex numbers, expressions, and lists.

e^(power)

e^(5)
148.4131591

e (Constant)

e (constant, **2nd** [**e**]) is stored as a constant on the TI-83 Plus. Press **2nd** [**e**] to copy **e** to the cursor location. In calculations, the TI-83 Plus uses 2.718281828459 for **e**.

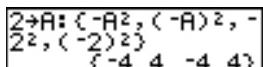
e
2.718281828

- (Negation)

- (negation, $\boxed{\text{-}}$) returns the negative of *value*. You can use - with real or complex numbers, expressions, lists, and matrices.

$-\text{value}$

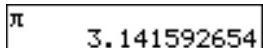
EOS™ rules (Chapter 1) determine when negation is evaluated. For example, $-\mathbf{A}^2$ returns a negative number, because squaring is evaluated before negation. Use parentheses to square a negated number, as in $(-\mathbf{A})^2$.

2 \rightarrow A: (-A², (-A)², -2², (-2)²)
{-4 4 -4 4}

Note: On the TI-83 Plus, the negation symbol (-) is shorter and higher than the subtraction sign (-), which is displayed when you press $\boxed{\text{-}}$.

π (Pi)

π (Pi, $\boxed{\text{2nd}} \ [\pi]$) is stored as a constant in the TI-83 Plus. In calculations, the TI-83 Plus uses 3.1415926535898 for π .

 π 3.141592654

MATH Operations

MATH Menu

To display the MATH menu, press **[MATH]**.

MATH NUM CPX PRB

- | | |
|----------------------|------------------------------------|
| 1: ►Frac | Displays the answer as a fraction. |
| 2: ►Dec | Displays the answer as a decimal. |
| 3: ${}^3\sqrt{}$ | Calculates the cube. |
| 4: $\sqrt[3]{}$ | Calculates the cube root. |
| 5: $x^{\frac{1}{n}}$ | Calculates the x^{th} root. |
| 6: fMin(| Finds the minimum of a function. |
| 7: fMax(| Finds the maximum of a function. |
| 8: nDeriv(| Computes the numerical derivative. |
| 9: fnInt(| Computes the function integral. |
| 0: Solver... | Displays the equation solver. |
-

►Frac, ►Dec

►Frac (display as a fraction) displays an answer as its rational equivalent. You can use ►Frac with real or complex numbers, expressions, lists, and matrices. If the answer cannot be simplified or the resulting denominator is more than three digits, the decimal equivalent is returned. You can only use ►Frac following *value*.

value ►Frac

►Dec (display as a decimal) displays an answer in decimal form. You can use ►Dec with real or complex numbers, expressions, lists, and matrices. You can only use ►Dec following *value*.

value ►Dec

```
1/2+1/3►Frac      5/6
Ans►Dec           .8333333333
```

${}^3\text{Cube}$, ${}^3\sqrt{}$ (Cube Root)

3 (cube) returns the cube of *value*. You can use 3 with real or complex numbers, expressions, lists, and square matrices.

value 3

${}^3\sqrt{}$ (cube root) returns the cube root of *value*. You can use ${}^3\sqrt{}$ with real or complex numbers, expressions, and lists.

${}^3\sqrt{(\textit{value})}$

```
{2,3,4,5} ${}^3$ 
{8 27 64 125}
 ${}^3\sqrt{\text{Ans}}$ 
{2 3 4 5}
```

$x\sqrt{ } \text{ (Root)}$

$x\sqrt{ }$ (x^{th} root) returns the x^{th} root of *value*. You can use $x\sqrt{ }$ with real or complex numbers, expressions, and lists.

$x^{th}root$ $x\sqrt{ } value$

```
| 5 * √32
|      2
```

fMin(, fMax(

fMin((function minimum) and **fMax(** (function maximum) return the value at which the local minimum or local maximum value of *expression* with respect to *variable* occurs, between *lower* and *upper* values for *variable*. **fMin(** and **fMax(** are not valid in *expression*. The accuracy is controlled by *tolerance* (if not specified, the default is 1E-5).

fMin(*expression, variable, lower, upper[, tolerance]*)

fMax(*expression, variable, lower, upper[, tolerance]*)

Note: In this guidebook, optional arguments and the commas that accompany them are enclosed in brackets ([]).

```
fMin(sin(A), A, -π
      , π)   -1.570797171
fMax(sin(A), A, -π
      , π)   1.570797171
```

nDeriv(

nDeriv((numerical derivative) returns an approximate derivative of *expression* with respect to *variable*, given the *value* at which to calculate the derivative and ε (if not specified, the default is 1E-3). **nDeriv(** is valid only for real numbers.

nDeriv(*expression, variable, value[, ε]*)

nDeriv(uses the symmetric difference quotient method, which approximates the numerical derivative value as the slope of the secant line through these points.

$$f'(x) = \frac{f(x + \varepsilon) - f(x - \varepsilon)}{2\varepsilon}$$

As ε becomes smaller, the approximation usually becomes more accurate.

```
nDeriv(A^3,A,5,.  
01)  
75.0001  
nDeriv(A^3,A,5,.  
0001)  
75
```

You can use **nDeriv(** once in *expression*. Because of the method used to calculate **nDeriv(**, the TI-83 Plus can return a false derivative value at a nondifferentiable point.

f_nInt(

f_nInt((function integral) returns the numerical integral (Gauss-Kronrod method) of *expression* with respect to *variable*, given *lower* limit, *upper* limit, and a *tolerance* (if not specified, the default is 1E-5). **f_nInt(** is valid only for real numbers.

f_nInt(expression,variable,lower,upper[,tolerance])

```
fnInt(A2,A,0,1)  
.3333333333
```

Tip: To speed the drawing of integration graphs (when **f_nInt(** is used in a **Y=** equation), increase the value of the **Xres** window variable before you press **[GRAPH]**.

Using the Equation Solver

Solver

Solver displays the equation solver, in which you can solve for any variable in an equation. The equation is assumed to be equal to zero. **Solver** is valid only for real numbers.

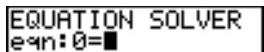
When you select **Solver**, one of two screens is displayed.

- The equation editor (see step 1 picture below) is displayed when the equation variable **eqn** is empty.
- The interactive solver editor is displayed when an equation is stored in **eqn**.

Entering an Expression in the Equation Solver

To enter an expression in the equation solver, assuming that the variable **eqn** is empty, follow these steps.

1. Select **0:Solver** from the **MATH** menu to display the equation editor.



EQUATION SOLVER
eqn: 0 = ■

2. Enter the expression in any of three ways.

- Enter the expression directly into the equation solver.
- Paste a **Y=** variable name from the **VARS Y-VARS** menu to the equation solver.
- Press **[2nd] [RCL]**, paste a **Y=** variable name from the **VARS Y-VARS** menu, and press **[ENTER]**. The expression is pasted to the equation solver.

The expression is stored to the variable **eqn** as you enter it.

```
EQUATION SOLVER  
eqn:=Q^3+P^2-125
```

3. Press **[ENTER]** or **[▼]**. The interactive solver editor is displayed.

```
Q^3+P^2-125=0  
Q=0  
P=0  
bound={-1e99, 1...}
```

- The equation stored in **eqn** is set equal to zero and displayed on the top line.
- Variables in the equation are listed in the order in which they appear in the equation. Any values stored to the listed variables also are displayed.
- The default lower and upper bounds appear in the last line of the editor (**bound={-1e99, 1e99}**).

- A ↓ is displayed in the first column of the bottom line if the editor continues beyond the screen.

Tip: To use the solver to solve an equation such as $K=.5MV^2$, enter $eqn:0=K-.5MV^2$ in the equation editor.

Entering and Editing Variable Values

When you enter or edit a value for a variable in the interactive solver editor, the new value is stored in memory to that variable.

You can enter an expression for a variable value. It is evaluated when you move to the next variable. Expressions must resolve to real numbers at each step during the iteration.

You can store equations to any **VARS Y-VARS** variables, such as **Y1** or **r6**, and then reference the variables in the equation. The interactive solver editor displays all variables of all **Y=** functions referenced in the equation.

```
\Y9BX^2-4AC  
\Y0=
```

```
EQUATION SOLVER  
eqn:0=Y9+7
```

```
Y9+7=0  
X=0  
A=0  
C=0  
bound=(-1e99,1...
```

Solving for a Variable in the Equation Solver

To solve for a variable using the equation solver after an equation has been stored to **eqn**, follow these steps.

1. Select **0:Solver** from the **MATH** menu to display the interactive solver editor, if not already displayed.

```
Q^3+P^2-125=0
Q=0
P=0
bound=(-1E99,1...
```

2. Enter or edit the value of each known variable. All variables, except the unknown variable, must contain a value. To move the cursor to the next variable, press **[ENTER]** or **▼**.

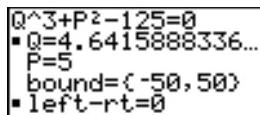
```
Q^3+P^2-125=0
Q=0
P=5■
bound=(-1E99,1...
```

3. Enter an initial guess for the variable for which you are solving. This is optional, but it may help find the solution more quickly. Also, for equations with multiple roots, the TI-83 Plus will attempt to display the solution that is closest to your guess.

```
Q^3+P^2-125=0
Q=4■
P=5
bound=(-1E99,1...
```

The default guess is calculated as $\frac{(upper+lower)}{2}$.

4. Edit **bound={lower,upper}**. *lower* and *upper* are the bounds between which the TI-83 Plus searches for a solution. This is optional, but it may help find the solution more quickly. The default is **bound={-1E99,1E99}**.
5. Move the cursor to the variable for which you want to solve and press **[ALPHA]** **[SOLVE]** (above the **[ENTER]** key).



Q³+P²-125=0
■ Q=4.6415888336...
P=5
bound={-50,50}
left-rt=0

- The solution is displayed next to the variable for which you solved. A solid square in the first column marks the variable for which you solved and indicates that the equation is balanced. An ellipsis shows that the value continues beyond the screen.

Note: When a number continues beyond the screen, be sure to press **[▼]** to scroll to the end of the number to see whether it ends with a negative or positive exponent. A very small number may appear to be a large number until you scroll right to see the exponent.

- The values of the variables are updated in memory.

- **left-rt=diff** is displayed in the last line of the editor. *diff* is the difference between the left and right sides of the equation. A solid square in the first column next to **left-rt=** indicates that the equation has been evaluated at the new value of the variable for which you solved.

Editing an Equation Stored to eqn

To edit or replace an equation stored to **eqn** when the interactive equation solver is displayed, press **◀** until the equation editor is displayed. Then edit the equation.

Equations with Multiple Roots

Some equations have more than one solution. You can enter a new initial guess or new bounds to look for additional solutions.

Further Solutions

After you solve for a variable, you can continue to explore solutions from the interactive solver editor. Edit the values of one or more variables. When you edit any variable value, the solid squares next to the previous solution and **left-rt=diff** disappear. Move the cursor to the variable for which you now want to solve and press **ALPHA** [SOLVE].

Controlling the Solution for Solver or solve(

The TI-83 Plus solves equations through an iterative process. To control that process, enter bounds that are relatively close to the solution and enter an initial guess within those bounds. This will help to find a solution more quickly. Also, it will define which solution you want for equations with multiple solutions.

Using solve(on the Home Screen or from a Program

The function **solve(** is available only from **CATALOG** or from within a program. It returns a solution (root) of *expression* for *variable*, given an initial *guess*, and *lower* and *upper* bounds within which the solution is sought. The default for *lower* is -1E99. The default for *upper* is 1E99. **solve(** is valid only for real numbers.

solve(*expression,variable,guess[,{lower,upper}]*)

expression is assumed equal to zero. The value of *variable* will not be updated in memory. *guess* may be a value or a list of two values. Values must be stored for every variable in *expression*, except *variable*, before *expression* is evaluated. *lower* and *upper* must be entered in list format.

```
5→P
      5
solve(Q^3+P^2-125
,0,4,{(-50,50)}
        4.641588834
```

MATH NUM (Number) Operations

MATH NUM Menu

To display the MATH NUM menu, press **MATH ▶**.

MATH NUM CPX PRB

- | | |
|-----------|-------------------------|
| 1: abs(| Absolute value |
| 2: round(| Round |
| 3: iPart(| Integer part |
| 4: fPart(| Fractional part |
| 5: int(| Greatest integer |
| 6: min(| Minimum value |
| 7: max(| Maximum value |
| 8: lcm(| Least common multiple |
| 9: gcd(| Greatest common divisor |
-

abs(

abs((absolute value) returns the absolute value of real or complex (modulus) numbers, expressions, lists, and matrices.

abs(*value*)

```
abs(-256)  
256  
abs((1.25, -5.67))  
(1.25 5.67)
```

Note: **abs(** is also available on the MATH CPX menu.

round(

round(returns a number, expression, list, or matrix rounded to *#decimals* (≤ 9). If *#decimals* is omitted, *value* is rounded to the digits that are displayed, up to 10 digits.

round(*value*[,*#decimals*])

```
round(pi, 4)  
3.1416
```

```
123456789012→C  
1.23456789e11  
C-round(C)  
12  
123456789012-123  
456789000  
12
```

iPart(, fPart(

iPart((integer part) returns the integer part or parts of real or complex numbers, expressions, lists, and matrices.

iPart(*value*)

fPart((fractional part) returns the fractional part or parts of real or complex numbers, expressions, lists, and matrices.

fPart(*value*)

```
iPart(-23.45)  
-23  
fPart(-23.45)  
-.45
```

int(

int((greatest integer) returns the largest integer \leq real or complex numbers, expressions, lists, and matrices.

int(*value*)

```
|int(-23.45)      -24|
```

Note: For a given *value*, the result of **int(** is the same as the result of **iPart(** for nonnegative numbers and negative integers, but one integer less than the result of **iPart(** for negative noninteger numbers.

min(, max(

min((minimum value) returns the smaller of *valueA* and *valueB* or the smallest element in *list*. If *listA* and *listB* are compared, **min(** returns a list of the smaller of each pair of elements. If *list* and *value* are compared, **min(** compares each element in *list* with *value*.

max((maximum value) returns the larger of *valueA* and *valueB* or the largest element in *list*. If *listA* and *listB* are compared, **max(** returns a list of the larger of each pair of elements. If *list* and *value* are compared, **max(** compares each element in *list* with *value*.

min(valueA,valueB)

min(list)

min(listA,listB)

min(list,value)

max(valueA,valueB)

max(list)

max(listA,listB)

max(list,value)

```
min(3,2+2)      3
min({3,4,5},4)  {3,4,4}
max({4,5,6})    6
```

Note: **min(** and **max(** also are available on the **LIST MATH** menu.

lcm(, gcd(

lcm(returns the least common multiple of *valueA* and *valueB*, both of which must be nonnegative integers. When *listA* and *listB* are specified, **lcm(** returns a list of the lcm of each pair of elements. If *list* and *value* are specified, **lcm(** finds the lcm of each element in *list* and *value*.

gcd(returns the greatest common divisor of *valueA* and *valueB*, both of which must be nonnegative integers. When *listA* and *listB* are specified, **gcd(** returns a list of the gcd of each pair of elements. If *list* and *value* are specified, **gcd(** finds the gcd of each element in *list* and *value*.

lcm(*valueA,valueB*)
lcm(*listA,listB*)
lcm(*list,value*)

gcd(*valueA,valueB*)
gcd(*listA,listB*)
gcd(*list,value*)

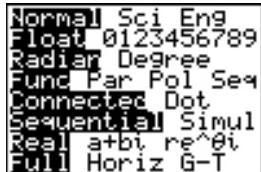
```
lcm(2,5)          10
gcd({48,66},{64,
122})           {16 2}
```

Entering and Using Complex Numbers

Complex-Number Modes

The TI-83 Plus displays complex numbers in rectangular form and polar form. To select a complex-number mode, press **MODE**, and then select either of the two modes.

- **a+bi** (rectangular-complex mode)
- **re^{θi}** (polar-complex mode)



On the TI-83 Plus, complex numbers can be stored to variables. Also, complex numbers are valid list elements.

In **Real** mode, complex-number results return an error, unless you entered a complex number as input. For example, in **Real** mode **ln(-1)** returns an error; in **a+bi** mode **ln(-1)** returns an answer.

Real mode

`ln(-1)`

↓

ERR:NONREAL ANS
1:Quit
2:Goto

a+bi mode

`ln(-1)`

↓

`ln(-1)`
3.141592654i

Entering Complex Numbers

Complex numbers are stored in rectangular form, but you can enter a complex number in rectangular form or polar form, regardless of the mode setting. The components of complex numbers can be real numbers or expressions that evaluate to real numbers; expressions are evaluated when the command is executed.

Note about Radian Versus Degree Mode

Radian mode is recommended for complex number calculations.

Internally, the TI-83 Plus converts all entered trigonometric values to radians, but it does not convert values for exponential, logarithmic, or hyperbolic functions.

In degree mode, complex identities such as $e^{i\theta} = \cos(\theta) + i \sin(\theta)$ are not generally true because the values for cos and sin are converted to radians, while those for $e^{\wedge}()$ are not. For example, $e^{\wedge}(i45) = \cos(45) + i \sin(45)$ is treated internally as $e^{\wedge}(i45) = \cos(\pi/4) + i \sin(\pi/4)$. Complex identities are always true in radian mode.

Interpreting Complex Results

Complex numbers in results, including list elements, are displayed in either rectangular or polar form, as specified by the mode setting or by a display conversion instruction. In the example below, polar-complex ($re^{\theta i}$) and Radian modes are set.

```
(2+i)-(1e^(π/4i))  
1.325654296e^(...)
```

Rectangular-Complex Mode

Rectangular-complex mode recognizes and displays a complex number in the form $a+bi$, where a is the real component, b is the imaginary component, and i is a constant equal to $\sqrt{-1}$.

```
ln(-1)  
3.141592654i
```

To enter a complex number in rectangular form, enter the value of a (*real component*), press $+$ or $-$, enter the value of b (*imaginary component*), and press $[2nd]$ [i] (*constant*).

real component(+ or -)*imaginary component i*

```
4+2i  
4+2i
```

Polar-Complex Mode

Polar-complex mode recognizes and displays a complex number in the form $r e^{\theta i}$, where r is the magnitude, e is the base of the natural log, θ is the angle, and i is a constant equal to $\sqrt{-1}$.

```
ln(-1)  
3.141592654e^(1...
```

To enter a complex number in polar form, enter the value of r (*magnitude*), press [2nd] [e^x] (exponential function), enter the value of θ (*angle*), press [2nd] [i] (constant), and then press [1].

magnitudee^(anglei)

```
10e^(pi/3i)  
10e^(1.04719755...
```

MATH CPX (Complex) Operations

MATH CPX Menu

To display the MATH CPX menu, press **MATH** ▶ ▶.

MATH NUM **CPX** PRB

- | | |
|-----------|--|
| 1: conj(| Returns the complex conjugate. |
| 2: real(| Returns the real part. |
| 3: imag(| Returns the imaginary part. |
| 4: angle(| Returns the polar angle. |
| 5: abs(| Returns the magnitude (modulus). |
| 6: ►Rect | Displays the result in rectangular form. |
| 7: ►Polar | Displays the result in polar form. |
-

conj(

conj((conjugate) returns the complex conjugate of a complex number or list of complex numbers.

conj(*a+bi*) returns *a-bi* in **a+bi** mode.

conj(*re^(θi)*) returns *re^(-θi)* in **re^θi** mode.

conj(3+4i)
3-4i

conj(3e^(4i))
3e^(2.283185307...)

real(

real((real part) returns the real part of a complex number or list of complex numbers.

real($a+bi$) returns a .

real($r e^{(\theta i)}$) returns $r \cos(\theta)$.

| | |
|-------------------|---|
| real(3+4i) | 3 |
|-------------------|---|

| | |
|-------------------------------------|--------------|
| real($3e^{(4i)}$) | -1.960930863 |
|-------------------------------------|--------------|

imag(

imag((imaginary part) returns the imaginary (nonreal) part of a complex number or list of complex numbers.

imag($a+bi$) returns b .

imag($r e^{(\theta i)}$) returns $r \sin(\theta)$.

| | |
|-------------------|---|
| imag(3+4i) | 4 |
|-------------------|---|

| | |
|-------------------------------------|--------------|
| imag($3e^{(4i)}$) | -2.270407486 |
|-------------------------------------|--------------|

angle(

angle(returns the polar angle of a complex number or list of complex numbers, calculated as $\tan^{-1}(b/a)$, where b is the imaginary part and a is the real part. The calculation is adjusted by $+\pi$ in the second quadrant or $-\pi$ in the third quadrant.

angle(*a+bi*) returns $\tan^{-1}(b/a)$.

angle(*re^(θi)*) returns θ , where $-\pi < \theta < \pi$.

angle(3+4i)
0.927295218

angle(3e^(4i))
-2.283185307

abs(

abs((absolute value) returns the magnitude (modulus), $\sqrt{(\text{real}^2 + \text{imag}^2)}$, of a complex number or list of complex numbers.

abs(*a+bi*) returns $\sqrt{a^2 + b^2}$.

abs(*re^(θi)*) returns r (magnitude).

abs(3+4i)
5

abs(3e^(4i))
3

►Rect

►Rect (display as rectangular) displays a complex result in rectangular form. It is valid only at the end of an expression. It is not valid if the result is real.

complex result►Rect returns $a+bi$.

```
∫(-2)►Rect  
1.414213562i
```

►Polar

►Polar (display as polar) displays a complex result in polar form. It is valid only at the end of an expression. It is not valid if the result is real.

complex result►Polar returns $re^{(\theta i)}$.

```
∫(-2)►Polar  
1.414213562e^(1...
```

MATH PRB (Probability) Operations

MATH PRB Menu

To display the MATH PRB menu, press **MATH** **1**.

MATH NUM CPX **PRB**

- | | |
|--------------|-------------------------------------|
| 1: rand | Random-number generator |
| 2: nPr | Number of permutations |
| 3: nCr | Number of combinations |
| 4: ! | Factorial |
| 5: randInt(| Random-integer generator |
| 6: randNorm(| Random # from Normal distribution |
| 7: randBin(| Random # from Binomial distribution |
-

rand

rand (random number) generates and returns one or more random numbers > 0 and < 1 . To generate a list of random-numbers, specify an integer > 1 for *numtrials* (number of trials). The default for *numtrials* is 1.

rand[(*numtrials*)]

Tip: To generate random numbers beyond the range of 0 to 1, you can include **rand** in an expression. For example, **rand5** generates a random number > 0 and < 5 .

With each **rand** execution, the TI-83 Plus generates the same random-number sequence for a given seed value. The TI-83 Plus factory-set seed value for **rand** is **0**. To generate a different random-number sequence, store any nonzero seed value to **rand**. To restore the factory-set seed value, store **0** to **rand** or reset the defaults (Chapter 18).

Note: The seed value also affects **randInt()**, **randNorm()**, and **randBin()** instructions.

```
rand      .1272157551  
          .2646513087  
1→rand           1  
rand(3)          (.7455607728 .8...)
```

nPr, nCr

nPr (number of permutations) returns the number of permutations of *items* taken *number* at a time. *items* and *number* must be nonnegative integers. Both *items* and *number* can be lists.

items **nPr** *number*

nCr (number of combinations) returns the number of combinations of *items* taken *number* at a time. *items* and *number* must be nonnegative integers. Both *items* and *number* can be lists.

items **nCr** *number*

| | | | |
|-------|-----|-------|-------|
| 5 | nPr | 2 | 20 |
| 5 | nCr | 2 | 10 |
| {2,3} | nPr | {2,2} | {2,6} |

! (Factorial)

! (factorial) returns the factorial of either an integer or a multiple of .5. For a list, it returns factorials for each integer or multiple of .5. *value* must be ≥ -5 and ≤ 69 .

value!

| | |
|----------|--------------|
| 6! | 720 |
| {5,4,6}! | {120 24 720} |

Note: The factorial is computed recursively using the relationship $(n+1)! = n \cdot n!$, until *n* is reduced to either 0 or $-1/2$. At that point, the definition $0! = 1$ or the definition $(-1/2)! = \sqrt{\pi}$ is used to complete the calculation. Hence:

$n! = n \cdot (n-1) \cdot (n-2) \cdot \dots \cdot 2 \cdot 1$, if *n* is an integer ≥ 0

$n! = n \cdot (n-1) \cdot (n-2) \cdot \dots \cdot 1/2 \cdot \sqrt{\pi}$, if $n+1/2$ is an integer ≥ 0

n! is an error, if neither *n* nor $n+1/2$ is an integer ≥ 0 .

(The variable *n* equals *value* in the syntax description above.)

randInt(

randInt((random integer) generates and displays a random integer within a range specified by *lower* and *upper* integer bounds. To generate a list of random numbers, specify an integer >1 for *numtrials* (number of trials); if not specified, the default is 1.

randInt(lower,upper[,numtrials])

```
randInt(1,6)+randInt(1,6)
6
randInt(1,6,3)
{2 1 5}
```

randNorm(

randNorm((random Normal) generates and displays a random real number from a specified Normal distribution. Each generated value could be any real number, but most will be within the interval $[\mu - 3(\sigma), \mu + 3(\sigma)]$. To generate a list of random numbers, specify an integer > 1 for *numtrials* (number of trials); if not specified, the default is 1.

randNorm(μ, σ [,numtrials])

```
randNorm(0,1)
.0772076175
randNorm(35,2,10
0)
{34.02701938 37...}
```

randBin(

randBin((random Binomial) generates and displays a random integer from a specified Binomial distribution. *numtrials* (number of trials) must be ≥ 1 . *prob* (probability of success) must be ≥ 0 and ≤ 1 . To generate a list of random numbers, specify an integer > 1 for *numsimulations* (number of simulations); if not specified, the default is 1.

randBin(*numtrials*,*prob*[,*numsimulations*])

```
randBin(5,.2)      3
randBin(7,.4,10)
{3 3 2 5 1 2 2 ...}
```

Note: The seed value stored to **rand** also affects **randInt()**, **randNorm()**, and **randBin()** instructions.

ANGLE Operations

ANGLE Menu

To display the ANGLE menu, press **2nd [ANGLE]**. The ANGLE menu displays angle indicators and instructions. The Radian/Degree mode setting affects the TI-83 Plus's interpretation of ANGLE menu entries.

| ANGLE | |
|---------------------------------------|--------------------------------------|
| 1: $^{\circ}$ | Degree notation |
| 2: ' | DMS minute notation |
| 3: r | Radian notation |
| 4: \blacktriangleright DMS | Displays as degree/minute/second |
| 5: $R\blacktriangleright r(\theta)$ | Returns r , given x and y |
| 6: $R\blacktriangleright\theta(x,y)$ | Returns θ , given x and y |
| 7: $P\blacktriangleright x(r,\theta)$ | Returns x , given r and θ |
| 8: $P\blacktriangleright y(r,\theta)$ | Returns y , given r and θ |

Entry Notation

DMS (degrees/minutes/seconds) entry notation comprises the degree symbol ($^{\circ}$), the minute symbol ('), and the second symbol ("). *degrees* must be a real number; *minutes* and *seconds* must be real numbers ≥ 0 .

degrees $^{\circ}$ *minutes*'*seconds*"

For example, enter for 30 degrees, 1 minute, 23 seconds. If the angle mode is not set to **Degree**, you must use \circ so that the TI-83 Plus can interpret the argument as degrees, minutes, and seconds.

Degree mode

```
sin(30°1'23")
.5003484441
```

Radian mode

```
sin(30°1'23")
-.9842129995
sin(30°1'23"°)
.5003484441
```

\circ (Degree)

\circ (degree) designates an angle or list of angles as degrees, regardless of the current angle mode setting. In **Radian** mode, you can use \circ to convert degrees to radians.

value \circ

{*value*1, *value*2, *value*3, *value*4, ..., *value* *n*} \circ

\circ also designates *degrees* (D) in DMS format.

' (minutes) designates *minutes* (M) in DMS format.

" (seconds) designates *seconds* (S) in DMS format.

Note: " is not on the ANGLE menu. To enter ", press **ALPHA** ["].

r (Radians)

r (radians) designates an angle or list of angles as radians, regardless of the current angle mode setting. In **Degree** mode, you can use r to convert radians to degrees.

*value*r

Degree mode

```
sin((π/4)r)
    .7071067812
sin(0, π/2)r
    (0 1)
(π/4)r
        45
```

►DMS

►DMS (degree/minute/second) displays *answer* in DMS format. The mode setting must be **Degree** for *answer* to be interpreted as degrees, minutes, and seconds. ►DMS is valid only at the end of a line.

answer►DMS

```
54°32'30" *2
    109.0833333
Ans►DMS
    109°5'0"
```

R►Pr(, R►Pθ(, P►Rx(, P►Ry(

R►Pr(converts rectangular coordinates to polar coordinates and returns r. R►Pθ(converts rectangular coordinates to polar coordinates and returns θ. x and y can be lists.

R►Pr(x,y), R►Pθ(x,y)

| | |
|------------|-------------|
| R►Pr(-1,0) | 1 |
| R►Pθ(-1,0) | 3.141592654 |

Note: Radian mode is set.

P►Rx(converts polar coordinates to rectangular coordinates and returns x. P►Ry(converts polar coordinates to rectangular coordinates and returns y. r and θ can be lists.

P►Rx(r,θ), P►Ry(r,θ)

| | |
|-----------|----|
| P►Rx(1,π) | -1 |
| P►Ry(1,π) | 0 |

Note: Radian mode is set.

TEST (Relational) Operations

TEST Menu

To display the TEST menu, press **[2nd] [TEST]**.

This operator... Returns 1 (true) if...

TEST LOGIC

- | | |
|-------|--------------------------|
| 1 : = | Equal |
| 2 : ≠ | Not equal to |
| 3 : > | Greater than |
| 4 : ≥ | Greater than or equal to |
| 5 : < | Less than |
| 6 : ≤ | Less than or equal to |
-

=, ≠, >, ≥, <, ≤

Relational operators compare *valueA* and *valueB* and return **1** if the test is true or **0** if the test is false. *valueA* and *valueB* can be real numbers, expressions, or lists. For = and ≠ only, *valueA* and *valueB* also can be matrices or complex numbers. If *valueA* and *valueB* are matrices, both must have the same dimensions.

Relational operators are often used in programs to control program flow and in graphing to control the graph of a function over specific values.

valueA=*valueB*

valueA≠*valueB*

valueA>*valueB*

valueA≥*valueB*

valueA<*valueB*

valueA≤*valueB*

```
25=26          0
(1,2,3)<3
(1,2,3)≠(3,2,1)
(1 0 1)
```

Using Tests

Relational operators are evaluated after mathematical functions according to EOS rules (Chapter 1).

- The expression **2+2=2+3** returns **0**. The TI-83 Plus performs the addition first because of EOS rules, and then it compares 4 to 5.
- The expression **2+(2=2)+3** returns **6**. The TI-83 Plus performs the relational test first because it is in parentheses, and then it adds 2, 1, and 3.

TEST LOGIC (Boolean) Operations

TEST LOGIC Menu

To display the TEST LOGIC menu, press **2nd [TEST]** ▶.

| This operator... | Returns a 1 (true) if... |
|------------------|---------------------------------------|
| TEST LOGIC | |
| 1: and | Both values are nonzero (true). |
| 2: or | At least one value is nonzero (true). |
| 3: xor | Only one value is zero (false). |
| 4: not(| The value is zero (false). |

Boolean Operators

Boolean operators are often used in programs to control program flow and in graphing to control the graph of the function over specific values. Values are interpreted as zero (false) or nonzero (true).

and, or, xor

and, **or**, and **xor** (exclusive or) return a value of **1** if an expression is true or **0** if an expression is false, according to the table below. *valueA* and *valueB* can be real numbers, expressions, or lists.

valueA **and** *valueB*

valueA **or** *valueB*

valueA **xor** *valueB*

| valueA | valueB | | and | or | xor |
|----------|----------|---------|-----|----|-----|
| $\neq 0$ | $\neq 0$ | returns | 1 | 1 | 0 |
| $\neq 0$ | 0 | returns | 0 | 1 | 1 |
| 0 | $\neq 0$ | returns | 0 | 1 | 1 |
| 0 | 0 | returns | 0 | 0 | 0 |

not(

not(*value*) returns 1 if *value* (which can be an expression) is 0.

not(*value*)

Using Boolean Operations

Boolean logic is often used with relational tests. In the following program, the instructions store 4 into C.

```
PROGRAM:BOOLEAN
:2→A:3→B
:If A=2 and B=3
:Then:4→C
:Else:5→C
:End
```

Chapter 3: **Function Graphing**

Getting Started: Graphing a Circle

Getting Started is a fast-paced introduction. Read the chapter for details.

Graph a circle of radius 10, centered on the origin in the standard viewing window. To graph this circle, you must enter separate formulas for the upper and lower portions of the circle. Then use ZSquare (zoom square) to adjust the display and make the functions appear as a circle.

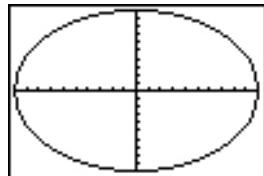
1. In Func mode, press **[Y=]** to display the **Y=** editor. Press **[2nd] [√]** **100** **[−]** **[X,T,Θ,n]** **[x²]** **[)]** **[ENTER]** to enter the expression $Y=\sqrt{100-X^2}$, which defines the top half of the circle.

| | | |
|--|--------------|--------------|
| Plot1 | Plot2 | Plot3 |
| $\checkmark Y_1 \equiv \sqrt{100-X^2}$ | | |
| $\checkmark Y_2 \equiv -Y_1$ | | |
| $\checkmark Y_3 =$ | | |
| $\checkmark Y_4 =$ | | |
| $\checkmark Y_5 =$ | | |
| $\checkmark Y_6 =$ | | |
| $\checkmark Y_7 =$ | | |

The expression $Y=-\sqrt{100-X^2}$ defines the bottom half of the circle. On the TI-83 Plus, you can define one function in terms of another. To define $Y_2=-Y_1$, press **[−]** to enter the negation sign. Press **[VARS]** **[▶]** to display the **VARS Y-VARS** menu. Then press **[ENTER]** to select **1:Function**. The **FUNCTION** secondary menu is displayed. Press **1** to select **1:Y1**.

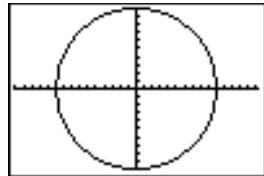
| | | |
|--|--------------|--------------|
| Plot1 | Plot2 | Plot3 |
| $\checkmark Y_1 \equiv \sqrt{100-X^2}$ | | |
| $\checkmark Y_2 \equiv -Y_1$ | | |
| $\checkmark Y_3 =$ | | |
| $\checkmark Y_4 =$ | | |
| $\checkmark Y_5 =$ | | |
| $\checkmark Y_6 =$ | | |
| $\checkmark Y_7 =$ | | |

2. Press **ZOOM** 6 to select **6:ZStandard**. This is a quick way to reset the window variables to the standard values. It also graphs the functions; you do not need to press **GRAPH**.



Notice that the functions appear as an ellipse in the standard viewing window.

3. To adjust the display so that each pixel represents an equal width and height, press **ZOOM** 5 to select **5:ZSquare**. The functions are replotted and now appear as a circle on the display.
4. To see the **ZSquare** window variables, press **WINDOW** and notice the new values for **Xmin**, **Xmax**, **Ymin**, and **Ymax**.



```
WINDOW
Xmin=-15.16129...
Xmax=15.161290...
Xscl=1
Ymin=-10
Ymax=10
Yscl=1
Xres=1
```

Defining Graphs

TI-83 Plus—Graphing Mode Similarities

Chapter 3 specifically describes function graphing, but the steps shown here are similar for each TI-83 Plus graphing mode. Chapters 4, 5, and 6 describe aspects that are unique to parametric graphing, polar graphing, and sequence graphing.

Defining a Graph

To define a graph in any graphing mode, follow these steps. Some steps are not always necessary.

1. Press **MODE** and set the appropriate graph mode.
2. Press **[Y=]** and enter, edit, or select one or more functions in the **Y=** editor.
3. Deselect stat plots, if necessary.
4. Set the graph style for each function.
5. Press **WINDOW** and define the viewing window variables.
6. Press **[2nd] [FORMAT]** and select the graph format settings.

Displaying and Exploring a Graph

After you have defined a graph, press **GRAPH** to display it. Explore the behavior of the function or functions using the TI-83 Plus tools described in this chapter.

Saving a Graph for Later Use

You can store the elements that define the current graph to any of 10 graph database variables (**GDB1** through **GDB9**, and **GDB0**; Chapter 8). To recreate the current graph later, simply recall the graph database to which you stored the original graph.

These types of information are stored in a **GDB**.

- **Y=** functions
- Graph style settings
- Window settings
- Format settings

You can store a picture of the current graph display to any of 10 graph picture variables (**Pic1** through **Pic9**, and **Pic0**; Chapter 8). Then you can superimpose one or more stored pictures onto the current graph.

Setting the Graph Modes

Checking and Changing the Graphing Mode

To display the mode screen, press **MODE**. The default settings are highlighted below. To graph functions, you must select **Func** mode before you enter values for the window variables and before you enter the functions.

```
Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^ei
Full Horiz G-T
```

The TI-83 Plus has four graphing modes.

- **Func** (function graphing)
- **Par** (parametric graphing; Chapter 4)
- **Pol** (polar graphing; Chapter 5)
- **Seq** (sequence graphing; Chapter 6)

Other mode settings affect graphing results. Chapter 1 describes each mode setting.

- **Float or 0123456789** (fixed) decimal mode affects displayed graph coordinates.
- **Radian or Degree** angle mode affects interpretation of some functions.
- **Connected or Dot** plotting mode affects plotting of selected functions.
- **Sequential or Simul** graphing-order mode affects function plotting when more than one function is selected.

Setting Modes from a Program

To set the graphing mode and other modes from a program, begin on a blank line in the program editor and follow these steps.

1. Press **MODE** to display the mode settings.
2. Press **▼**, **►**, **◀**, and **▲** to place the cursor on the mode that you want to select.
3. Press **ENTER** to paste the mode name to the cursor location.

The mode is changed when the program is executed.

Defining Functions

Displaying Functions in the Y= Editor

To display the **Y=** editor, press **[Y=]**. You can store up to 10 functions to the function variables **Y₁** through **Y₉**, and **Y₀**. You can graph one or more defined functions at once. In this example, functions **Y₁** and **Y₂** are defined and selected.

```
Plot1 Plot2 Plot3
Y1=Γ(100-X²)
Y2= -Y1
Y3=
Y4=
Y5=
Y6=
Y7=
```

Defining or Editing a Function

To define or edit a function, follow these steps.

1. Press **[Y=]** to display the **Y=** editor.
2. Press **[▼]** to move the cursor to the function you want to define or edit.
To erase a function, press **[CLEAR]**.
3. Enter or edit the expression to define the function.

- You may use functions and variables (including matrices and lists) in the expression. When the expression evaluates to a nonreal number, the value is not plotted; no error is returned.
- The independent variable in the function is **X**. **Func** mode defines **[X,T,Θ,n]** as **X**. To enter **X**, press **[X,T,Θ,n]** or press **[ALPHA] [X]**.
- When you enter the first character, the **=** is highlighted, indicating that the function is selected.

As you enter the expression, it is stored to the variable **Y_n** as a user-defined function in the **Y=** editor.

4. Press **[ENTER]** or **▼** to move the cursor to the next function.

Defining a Function from the Home Screen or a Program

To define a function from the home screen or a program, begin on a blank line and follow these steps.

1. Press **[ALPHA] ["]**, enter the expression, and then press **[ALPHA] ["]** again.
2. Press **[STO►]**.
3. Press **[VARS] ▶ 1** to select **1:Function** from the **VARS Y-VARS** menu.

4. Select the function name, which pastes the name to the cursor location on the home screen or program editor.
5. Press **[ENTER]** to complete the instruction.

"expression" \rightarrow Y_n

" X^2 " \rightarrow Y_1 Done Plot1 Plot2 Plot3
 $\backslash Y_1 \blacksquare X^2$

When the instruction is executed, the TI-83 Plus stores the expression to the designated variable Y_n , selects the function, and displays the message **Done**.

Evaluating $Y=$ Functions in Expressions

You can calculate the value of a $Y=$ function Y_n at a specified *value* of X . A list of *values* returns a list.

$Y_n(value)$

$Y_n(\{value_1,value_2,value_3,\dots,value_n\})$

Plot1 Plot2 Plot3
 $\backslash Y_1 \blacksquare .2X^3 - 2X + 6$
 $\backslash Y_2 =$
 $\backslash Y_3 =$

$Y_1(0)$ 6
 $Y_1(\{0,1,2,3,4\})$
 $\{6 \ 4.2 \ 3.6 \ 3.4 \ \dots\}$

Selecting and Deselecting Functions

Selecting and Deselecting a Function

You can select and deselect (turn on and turn off) a function in the $Y=$ editor. A function is selected when the = sign is highlighted. The TI-83 Plus graphs only the selected functions. You can select any or all functions Y_1 through Y_9 , and Y_0 .

To select or deselect a function in the $Y=$ editor, follow these steps.

1. Press $\boxed{Y=}$ to display the $Y=$ editor.
2. Move the cursor to the function you want to select or deselect.
3. Press $\boxed{\square}$ to place the cursor on the function's = sign.
4. Press $\boxed{\text{ENTER}}$ to change the selection status.

When you enter or edit a function, it is selected automatically. When you clear a function, it is deselected.

Turning On or Turning Off a Stat Plot in the Y= Editor

To view and change the on/off status of a stat plot in the **Y=** editor, use **Plot1 Plot2 Plot3** (the top line of the **Y=** editor). When a plot is on, its name is highlighted on this line.

To change the on/off status of a stat plot from the **Y=** editor, press **▲** and **▶** to place the cursor on **Plot1**, **Plot2**, or **Plot3**, and then press **[ENTER]**.

```
Plot1 Plot2 Plot3
\Y1=.2X^3-2X+6
\Y2=-\Y1
\Y3=2X+X^2
\Y4=
\Y5=
\Y6=
\Y7=
```

Plot1 is turned on.
Plot2 and Plot3 are turned off.

Selecting and Deselecting Functions from the Home Screen or a Program

To select or deselect a function from the home screen or a program, begin on a blank line and follow these steps.

1. Press **VARS** **▶** to display the **VARS Y-VARS** menu.
2. Select **4:On/Off** to display the **ON/OFF** secondary menu.

3. Select **1:FnOn** to turn on one or more functions or **2:FnOff** to turn off one or more functions. The instruction you select is copied to the cursor location.
4. Enter the number (**1** through **9**, or **0**; not the variable **Y_n**) of each function you want to turn on or turn off.
 - If you enter two or more numbers, separate them with commas.
 - To turn on or turn off all functions, do not enter a number after **FnOn** or **FnOff**.

FnOn[function#,function#, . . . ,function n]

FnOff[function#,function#, . . . ,function n]

5. Press **ENTER**. When the instruction is executed, the status of each function in the current mode is set and **Done** is displayed.

For example, in **Func** mode, **FnOff :FnOn 1,3** turns off all functions in the **Y=** editor, and then turns on **Y1** and **Y3**.

FnOff :FnOn 1,3
Done

Plot1 Plot2 Plot3
Y1=.2X³-2X+6
Y2=-Y1
Y3=X²
Y4=
Y5=
Y6=
Y7=

Setting Graph Styles for Functions

Graph Style Icons in the Y= Editor

This table describes the graph styles available for function graphing. Use the styles to visually differentiate functions to be graphed together. For example, you can set Y_1 as a solid line, Y_2 as a dotted line, and Y_3 as a thick line.

| Icon | Style | Description |
|------|---------|--|
| \ | Line | A solid line connects plotted points; this is the default in Connected mode |
| ⌘ | Thick | A thick solid line connects plotted points |
| ▀ | Above | Shading covers the area above the graph |
| ▀ | Below | Shading covers the area below the graph |
| ◐ | Path | A circular cursor traces the leading edge of the graph and draws a path |
| ◑ | Animate | A circular cursor traces the leading edge of the graph without drawing a path |
| • | Dot | A small dot represents each plotted point; this is the default in Dot mode |

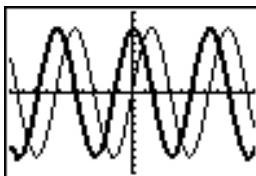
Note: Some graph styles are not available in all graphing modes. Chapters 4, 5, and 6 list the styles for **Par**, **Pol**, and **Seq** modes.

Setting the Graph Style

To set the graph style for a function, follow these steps.

1. Press **[Y=]** to display the **Y=** editor.
2. Press **[▼]** and **[▲]** to move the cursor to the function.
3. Press **[◀]** **[◀]** to move the cursor left, past the **=** sign, to the graph style icon in the first column. The insert cursor is displayed. (Steps 2 and 3 are interchangeable.)
4. Press **[ENTER]** repeatedly to rotate through the graph styles. The seven styles rotate in the same order in which they are listed in the table above.
5. Press **[▶]**, **[▲]**, or **[▼]** when you have selected a style.

```
Plot1 Plot2 Plot3
\ny1=8sin(X)
\ny2=8cos(X)
\ny3=
\ny4=
\ny5=
\ny6=
\ny7=
```

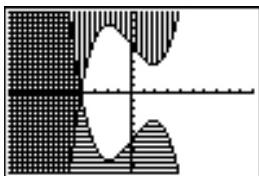


Shading Above and Below

When you select \blacksquare or \blacktriangle for two or more functions, the TI-83 Plus rotates through four shading patterns.

- Vertical lines shade the first function with a \blacksquare or \blacktriangle graph style.
- Horizontal lines shade the second.
- Negatively sloping diagonal lines shade the third.
- Positively sloping diagonal lines shade the fourth.
- The rotation returns to vertical lines for the fifth \blacksquare or \blacktriangle function, repeating the order described above.

When shaded areas intersect, the patterns overlap.



Note: When \blacksquare or \blacktriangle is selected for a $Y=$ function that graphs a family of curves, such as $Y1=\{1,2,3\}X$, the four shading patterns rotate for each member of the family of curves.

Setting a Graph Style from a Program

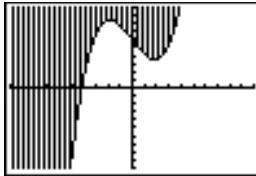
To set the graph style from a program, select **H:GraphStyle(** from the **PRGM CTL** menu. To display this menu, press **[PRGM]** while in the program editor. *function#* is the number of the **Y=** function name in the current graphing mode. *graphstyle#* is an integer from 1 to 7 that corresponds to the graph style, as shown below.

| | | |
|-----------------------|------------------------|-------------------------|
| 1 = \ (line) | 2 = \ \ (thick) | 3 = \ (above) |
| 4 = \ (below) | 5 = \o (path) | 6 = \o (animate) |
| | | 7 = \cdot (dot) |

GraphStyle(function#,graphstyle#)

For example, when this program is executed in **Func** mode,
GraphStyle(1,3) sets **Y1** to **\|** (above).

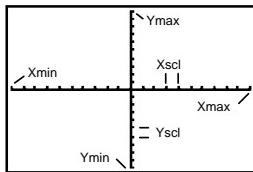
```
PROGRAM:SHADE
:".2X^3-2X+6"→Y1
:GraphStyle(1,3)
:DispGraph
```



Setting the Viewing Window Variables

The TI-83 Plus Viewing Window

The viewing window is the portion of the coordinate plane defined by **Xmin**, **Xmax**, **Ymin**, and **Ymax**. **Xscl** (X scale) defines the distance between tick marks on the x-axis. **Yscl** (Y scale) defines the distance between tick marks on the y-axis. To turn off tick marks, set **Xscl=0** and **Yscl=0**.



```
WINDOW  
Xmin=-10  
Xmax=10  
Xscl=1  
Ymin=-10  
Ymax=10  
Yscl=1  
Xres=1
```

Displaying the Window Variables

To display the current window variable values, press **WINDOW**. The window editor above and to the right shows the default values in **Func** graphing mode and **Radian** angle mode. The window variables differ from one graphing mode to another.

Xres sets pixel resolution (1 through 8) for function graphs only. The default is 1.

- At **Xres=1**, functions are evaluated and graphed at each pixel on the x-axis.

- At **Xres=8**, functions are evaluated and graphed at every eighth pixel along the x-axis.

Tip: Small **Xres** values improve graph resolution but may cause the TI-83 Plus to draw graphs more slowly.

Changing a Window Variable Value

To change a window variable value from the window editor, follow these steps.

1. Press **▼** or **▲** to move the cursor to the window variable you want to change.
2. Edit the value, which can be an expression.
 - Enter a new value, which clears the original value.
 - Move the cursor to a specific digit, and then edit it.
3. Press **[ENTER]**, **▼**, or **▲**. If you entered an expression, the TI-83 Plus evaluates it. The new value is stored.

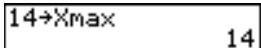
Note: **Xmin<Xmax** and **Ymin<Ymax** must be true in order to graph.

Storing to a Window Variable from the Home Screen or a Program

To store a value, which can be an expression, to a window variable, begin on a blank line and follow these steps.

1. Enter the value you want to store.
2. Press **[STO►]**.
3. Press **[VARS]** to display the **VARS** menu.
4. Select **1:Window** to display the **Func** window variables (**x/y** secondary menu).
 - Press **▶** to display the **Par** and **Pol** window variables (**T/θ** secondary menu).
 - Press **▶ ▶** to display the **Seq** window variables (**u/v/w** secondary menu).
5. Select the window variable to which you want to store a value. The name of the variable is pasted to the current cursor location.
6. Press **[ENTER]** to complete the instruction.

When the instruction is executed, the TI-83 Plus stores the value to the window variable and displays the value.



14->**Xmax**
14

ΔX and ΔY

The variables **ΔX** and **ΔY** (items **8** and **9** on the **VARS (1:Window) X/Y** secondary menu) define the distance from the center of one pixel to the center of any adjacent pixel on a graph (graphing accuracy). **ΔX** and **ΔY** are calculated from **Xmin**, **Xmax**, **Ymin**, and **Ymax** when you display a graph.

$$\Delta X = \frac{(X_{\text{max}} - X_{\text{min}})}{94} \qquad \Delta Y = \frac{(Y_{\text{max}} - Y_{\text{min}})}{62}$$

You can store values to **ΔX** and **ΔY**. If you do, **Xmax** and **Ymax** are calculated from **ΔX**, **Xmin**, **ΔY**, and **Ymin**.

Setting the Graph Format

Displaying the Format Settings

To display the format settings, press **[2nd] [FORMAT]**. The default settings are highlighted below.

| | | |
|----------|----------|-------------------------------------|
| RectGC | PolarGC | Sets cursor coordinates. |
| CoordOn | CoordOff | Sets coordinates display on or off. |
| GridOff | GridOn | Sets grid off or on. |
| AxesOn | AxesOff | Sets axes on or off. |
| LabelOff | LabelOn | Sets axes label off or on. |
| ExprOn | ExprOff | Sets expression display on or off. |

Format settings define a graph's appearance on the display. Format settings apply to all graphing modes. **Seq** graphing mode has an additional mode setting (Chapter 6).

Changing a Format Setting

To change a format setting, follow these steps.

1. Press **[▼], [▶], [▲], and [◀]** as necessary to move the cursor to the setting you want to select.
2. Press **[ENTER]** to select the highlighted setting.

RectGC, PolarGC

RectGC (rectangular graphing coordinates) displays the cursor location as rectangular coordinates X and Y .

PolarGC (polar graphing coordinates) displays the cursor location as polar coordinates R and θ .

The **RectGC/PolarGC** setting determines which variables are updated when you plot the graph, move the free-moving cursor, or trace.

- **RectGC** updates X and Y ; if **CoordOn** format is selected, X and Y are displayed.
- **PolarGC** updates X , Y , R , and θ ; if **CoordOn** format is selected, R and θ are displayed.

CoordOn, CoordOff

CoordOn (coordinates on) displays the cursor coordinates at the bottom of the graph. If **ExprOff** format is selected, the function number is displayed in the top-right corner.

CoordOff (coordinates off) does not display the function number or coordinates.

GridOff, GridOn

Grid points cover the viewing window in rows that correspond to the tick marks on each axis.

GridOff does not display grid points.

GridOn displays grid points.

AxesOn, AxesOff

AxesOn displays the axes.

AxesOff does not display the axes.

This overrides the **LabelOff/LabelOn** format setting.

LabelOff, LabelOn

LabelOff and **LabelOn** determine whether to display labels for the axes (X and Y), if **AxesOn** format is also selected.

ExprOn, ExprOff

ExprOn and **ExprOff** determine whether to display the **Y=** expression when the trace cursor is active. This format setting also applies to stat plots.

When **ExprOn** is selected, the expression is displayed in the top-left corner of the graph screen.

When **ExprOff** and **CoordOn** both are selected, the number in the top-right corner specifies which function is being traced.

Displaying Graphs

Displaying a New Graph

To display the graph of the selected function or functions, press **[GRAPH]**. **TRACE**, **ZOOM** instructions, and **CALC** operations display the graph automatically. As the TI-83 Plus plots the graph, the busy indicator is on. As the graph is plotted, **X** and **Y** are updated.

Pausing or Stopping a Graph

While plotting a graph, you can pause or stop graphing.

- Press **[ENTER]** to pause; then press **[ENTER]** to resume.
- Press **[ON]** to stop; then press **[GRAPH]** to redraw.

Smart Graph

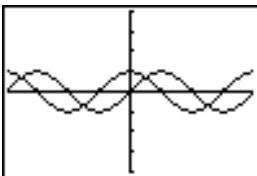
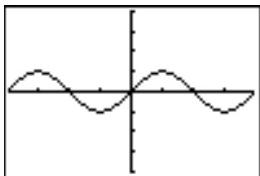
Smart Graph is a TI-83 Plus feature that redisplays the last graph immediately when you press **[GRAPH]**, but only if all graphing factors that would cause replotting have remained the same since the graph was last displayed.

If you performed any of these actions since the graph was last displayed, the TI-83 Plus will replot the graph based on new values when you press **[GRAPH]**.

- Changed a mode setting that affects graphs
- Changed a function in the current picture
- Selected or deselected a function or stat plot
- Changed the value of a variable in a selected function
- Changed a window variable or graph format setting
- Cleared drawings by selecting **ClrDraw**
- Changed a stat plot definition

Overlaying Functions on a Graph

On the TI-83 Plus, you can graph one or more new functions without replotting existing functions. For example, store $\sin(X)$ to Y_1 in the **Y=** editor and press **[GRAPH]**. Then store $\cos(X)$ to Y_2 and press **[GRAPH]** again. The function Y_2 is graphed on top of Y_1 , the original function.

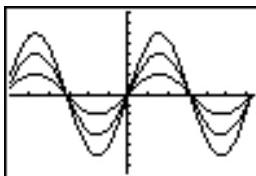


Graphing a Family of Curves

If you enter a list (Chapter 11) as an element in an expression, the TI-83 Plus plots the function for each value in the list, thereby graphing a family of curves. In **Simul** graphing-order mode, it graphs all functions sequentially for the first element in each list, and then for the second, and so on.

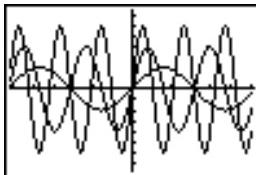
$\{2,4,6\}\sin(X)$ graphs three functions: $2 \sin(X)$, $4 \sin(X)$, and $6 \sin(X)$.

```
Plot1 Plot2 Plot3  
Y1={2,4,6}sin(X)  
Y2=  
Y3=  
Y4=  
Y5=  
Y6=
```



$\{2,4,6\}\sin(\{1,2,3\}X)$ graphs $2 \sin(X)$, $4 \sin(2X)$, and $6 \sin(3X)$.

```
Plot1 Plot2 Plot3  
Y1={2,4,6}sin({  
1,2,3}X)  
Y2=  
Y3=  
Y4=  
Y5=  
Y6=
```



Note: When using more than one list, the lists must have the same dimensions.

Exploring Graphs with the Free-Moving Cursor

Free-Moving Cursor

When a graph is displayed, press \blacktriangleleft , \triangleright , \blacktriangleup , or \blacktriangledown to move the cursor around the graph. When you first display the graph, no cursor is visible. When you press \blacktriangleleft , \triangleright , \blacktriangleup , or \blacktriangledown , the cursor moves from the center of the viewing window.

As you move the cursor around the graph, the coordinate values of the cursor location are displayed at the bottom of the screen if **CoordOn** format is selected. The **Float/Fix** decimal mode setting determines the number of decimal digits displayed for the coordinate values.

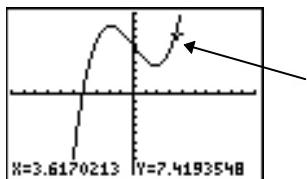
To display the graph with no cursor and no coordinate values, press **CLEAR** or **ENTER**. When you press \blacktriangleleft , \triangleright , \blacktriangleup , or \blacktriangledown , the cursor moves from the same position.

Graphing Accuracy

The free-moving cursor moves from pixel to pixel on the screen. When you move the cursor to a pixel that appears to be on the function, the cursor may be near, but not actually on, the function. The coordinate

value displayed at the bottom of the screen actually may not be a point on the function. To move the cursor along a function, use **TRACE**.

The coordinate values displayed as you move the cursor approximate actual math coordinates, *accurate to within the width and height of the pixel. As **Xmin**, **Xmax**, **Ymin**, and **Ymax** get closer together (as in a **Zoom In**) graphing accuracy increases, and the coordinate values more closely approximate the math coordinates.



Free-moving cursor “on” the curve

Exploring Graphs with TRACE

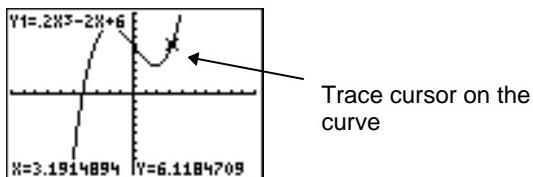
Beginning a Trace

Use **TRACE** to move the cursor from one plotted point to the next along a function. To begin a trace, press **TRACE**. If the graph is not displayed already, press **TRACE** to display it. The trace cursor is on the first selected function in the **Y=** editor, at the middle **X** value on the screen. The cursor coordinates are displayed at the bottom of the screen if **CoordOn** format is selected. The **Y=** expression is displayed in the top-left corner of the screen, if **ExprOn** format is selected.

Moving the Trace Cursor

| To move the TRACE cursor | do this: |
|--|--|
| To the previous or next plotted point, | press ◀ or ▶ . |
| Five plotted points on a function (Xres affects this), | press 2nd ▲ or 2nd ▼ . |
| To any valid X value on a function, | enter a value, and then press ENTER . |
| From one function to another, | press ▲ or ▼ . |

When the trace cursor moves along a function, the Y value is calculated from the X value; that is, $Y=Y_n(X)$. If the function is undefined at an X value, the Y value is blank.



Trace cursor on the curve

If you move the trace cursor beyond the top or bottom of the screen, the coordinate values at the bottom of the screen continue to change appropriately.

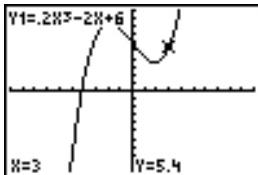
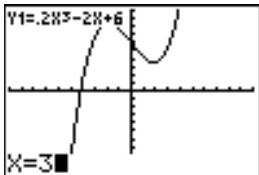
Moving the Trace Cursor from Function to Function

To move the trace cursor from function to function, press $\boxed{\square}$ and $\boxed{\triangle}$. The cursor follows the order of the selected functions in the $Y=$ editor. The trace cursor moves to each function at the same X value. If **ExprOn** format is selected, the expression is updated.

Moving the Trace Cursor to Any Valid X Value

To move the trace cursor to any valid X value on the current function, enter the value. When you enter the first digit, an $X=$ prompt and the number you entered are displayed in the bottom-left corner of the screen. You can enter an expression at the $X=$ prompt. The value must

be valid for the current viewing window. When you have completed the entry, press **ENTER** to move the cursor.



Note: This feature does not apply to stat plots.

Panning to the Left or Right

If you trace a function beyond the left or right side of the screen, the viewing window automatically pans to the left or right. **Xmin** and **Xmax** are updated to correspond to the new viewing window.

Quick Zoom

While tracing, you can press **ENTER** to adjust the viewing window so that the cursor location becomes the center of the new viewing window, even if the cursor is above or below the display. This allows panning up and down. After Quick Zoom, the cursor remains in **TRACE**.

Leaving and Returning to TRACE

When you leave and return to **TRACE**, the trace cursor is displayed in the same location it was in when you left **TRACE**, unless Smart Graph has replotted the graph.

Using TRACE in a Program

On a blank line in the program editor, press **[TRACE]**. The instruction **Trace** is pasted to the cursor location. When the instruction is encountered during program execution, the graph is displayed with the trace cursor on the first selected function. As you trace, the cursor coordinate values are updated. When you finish tracing the functions, press **[ENTER]** to resume program execution.

Exploring Graphs with the ZOOM Instructions

ZOOM Menu

To display the **ZOOM** menu, press **ZOOM**. You can adjust the viewing window of the graph quickly in several ways. All **ZOOM** instructions are accessible from programs.

ZOOM MEMORY

- | | |
|-------------|---|
| 1:ZBox | Draws a box to define the viewing window. |
| 2:Zoom In | Magnifies the graph around the cursor. |
| 3:Zoom Out | Views more of a graph around the cursor. |
| 4:ZDecimal | Sets ΔX and ΔY to 0.1. |
| 5:ZSquare | Sets equal-size pixels on the X and Y axes. |
| 6:ZStandard | Sets the standard window variables. |
| 7:ZTrig | Sets the built-in trig window variables. |
| 8:ZInteger | Sets integer values on the X and Y axes. |
| 9:ZoomStat | Sets the values for current stat lists. |
| 0:ZoomFit | Fits YMin and YMax between XMin and XMax. |
-

Zoom Cursor

When you select **1:ZBox**, **2:Zoom In**, or **3:Zoom Out**, the cursor on the graph becomes the zoom cursor (+), a smaller version of the free-moving cursor (+).

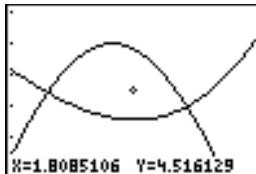
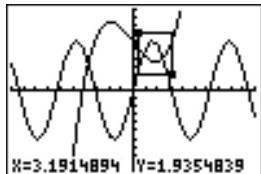
ZBox

To define a new viewing window using **ZBox**, follow these steps.

1. Select **1:ZBox** from the **zoom** menu. The zoom cursor is displayed at the center of the screen.
2. Move the zoom cursor to any spot you want to define as a corner of the box, and then press **ENTER**. When you move the cursor away from the first defined corner, a small, square dot indicates the spot.
3. Press **◀**, **▲**, **▶**, or **▼**. As you move the cursor, the sides of the box lengthen or shorten proportionately on the screen.

Note: To cancel **ZBox** before you press **ENTER**, press **CLEAR**.

4. When you have defined the box, press **ENTER** to replot the graph.



To use **ZBox** to define another box within the new graph, repeat steps 2 through 4. To cancel **ZBox**, press **CLEAR**.

Zoom In, Zoom Out

Zoom In magnifies the part of the graph that surrounds the cursor location. **Zoom Out** displays a greater portion of the graph, centered on the cursor location. The **XFact** and **YFact** settings determine the extent of the zoom.

To zoom in on a graph, follow these steps.

1. Check **XFact** and **YFact**; change as needed.
2. Select **2:Zoom In** from the **ZOOM** menu. The zoom cursor is displayed.
3. Move the zoom cursor to the point that is to be the center of the new viewing window.

4. Press **[ENTER]**. The TI-83 Plus adjusts the viewing window by **XFact** and **YFact**; updates the window variables; and replots the selected functions, centered on the cursor location.
5. Zoom in on the graph again in either of two ways.
 - To zoom in at the same point, press **[ENTER]**.
 - To zoom in at a new point, move the cursor to the point that you want as the center of the new viewing window, and then press **[ENTER]**.

To zoom out on a graph, select **3:Zoom Out** and repeat steps 3 through 5.

To cancel **Zoom In** or **Zoom Out**, press **[CLEAR]**.

ZDecimal

ZDecimal replots the functions immediately. It updates the window variables to preset values, as shown below. These values set ΔX and ΔY equal to **0.1** and set the **X** and **Y** value of each pixel to one decimal place.

Xmin=-4.7

Ymin=-3.1

Xmax=4.7

Ymax=3.1

Xscl=1

Yscl=1

ZSquare

ZSquare replots the functions immediately. It redefines the viewing window based on the current values of the window variables. It adjusts in only one direction so that $\Delta X = \Delta Y$, which makes the graph of a circle look like a circle. **Xscl** and **Yscl** remain unchanged. The midpoint of the current graph (not the intersection of the axes) becomes the midpoint of the new graph.

ZStandard

ZStandard replots the functions immediately. It updates the window variables to the standard values shown below.

Xmin=-10

Ymin=-10

Xres=1

Xmax=10

Ymax=10

Xscl=1

Yscl=1

ZTrig

ZTrig replots the functions immediately. It updates the window variables to preset values that are appropriate for plotting trig functions. Those preset values in **Radian** mode are shown below.

Xmin=-(47/24) π

Ymin=-4

Xmax=(47/24) π

Ymax=4

Xscl= $\pi/2$

Yscl=1

ZInteger

ZInteger redefines the viewing window to the dimensions shown below. To use **ZInteger**, move the cursor to the point that you want to be the center of the new window, and then press **ENTER**; **ZInteger** replots the functions.

| | |
|--------------|-----------|
| $\Delta X=1$ | $Xscl=10$ |
| $\Delta Y=1$ | $Yscl=10$ |

ZoomStat

ZoomStat redefines the viewing window so that all statistical data points are displayed. For regular and modified box plots, only **Xmin** and **Xmax** are adjusted.

ZoomFit

ZoomFit replots the functions immediately. **ZoomFit** recalculates **YMin** and **YMax** to include the minimum and maximum Y values of the selected functions between the current **XMin** and **XMax**. **XMin** and **XMax** are not changed.

Using ZOOM MEMORY

ZOOM MEMORY Menu

To display the **ZOOM MEMORY** menu, press **ZOOM** ▶.

ZOOM **MEMORY**

- | | |
|------------------|---|
| 1: ZPrevious | Uses the previous viewing window. |
| 2: ZoomSto | Stores the user-defined window. |
| 3: ZoomRcl | Recalls the user-defined window. |
| 4: SetFactors... | Changes Zoom In and Zoom Out factors. |
-

ZPrevious

ZPrevious replots the graph using the window variables of the graph that was displayed before you executed the last **zoom** instruction.

ZoomSto

ZoomSto immediately stores the current viewing window. The graph is displayed, and the values of the current window variables are stored in the user-defined **zoom** variables **ZXmin**, **ZXmax**, **ZXscl**, **ZYmin**, **ZYmax**, **ZYscl**, and **ZXres**.

These variables apply to all graphing modes. For example, changing the value of **ZXmin** in **Func** mode also changes it in **Par** mode.

ZoomRcl

ZoomRcl graphs the selected functions in a user-defined viewing window. The user-defined viewing window is determined by the values stored with the **ZoomSto** instruction. The window variables are updated with the user-defined values, and the graph is plotted.

ZOOM FACTORS

The zoom factors, **XFact** and **YFact**, are positive numbers (not necessarily integers) greater than or equal to 1. They define the magnification or reduction factor used to **Zoom In** or **Zoom Out** around a point.

Checking XFact and YFact

To display the **ZOOM FACTORS** screen, where you can review the current values for **XFact** and **YFact**, select **4:SetFactors** from the **ZOOM MEMORY** menu. The values shown are the defaults.

```
ZOOM FACTORS
XFact=4
YFact=4
```

Changing XFact and YFact

You can change **XFact** and **YFact** in either of two ways.

- Enter a new value. The original value is cleared automatically when you enter the first digit.
- Place the cursor on the digit you want to change, and then enter a value or press **DEL** to delete it.

Using ZOOM MEMORY Menu Items from the Home Screen or a Program

From the home screen or a program, you can store directly to any of the user-defined **ZOOM** variables.

```
-5→ZXmin:5→ZXmax  
      5
```

From a program, you can select the **ZoomSto** and **ZoomRcl** instructions from the **ZOOM MEMORY** menu.

Using the CALC (Calculate) Operations

CALCULATE Menu

To display the CALCULATE menu, press **2nd** [CALC]. Use the items on this menu to analyze the current graph functions.

CALCULATE

- | | |
|------------------|--|
| 1:value | Calculates a function Y value for a given X. |
| 2:zero | Finds a zero (x-intercept) of a function. |
| 3:minimum | Finds a minimum of a function. |
| 4:maximum | Finds a maximum of a function. |
| 5:intersect | Finds an intersection of two functions. |
| 6:dy/dx | Finds a numeric derivative of a function. |
| 7: $\int f(x)dx$ | Finds a numeric integral of a function. |
-

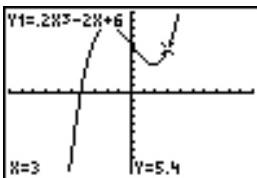
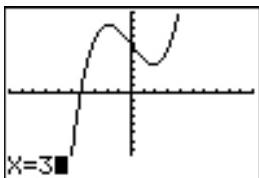
value

value evaluates one or more currently selected functions for a specified value of **X**.

Note: When a value is displayed for **X**, press **CLEAR** to clear the value. When no value is displayed, press **CLEAR** to cancel the **value** operation.

To evaluate a selected function at x , follow these steps.

1. Select **1:value** from the **CALCULATE** menu. The graph is displayed with **X=** in the bottom-left corner.
2. Enter a real value, which can be an expression, for X between X_{\min} and X_{\max} .
3. Press **[ENTER]**.



The cursor is on the first selected function in the **Y=** editor at the X value you entered, and the coordinates are displayed, even if **CoordOff** format is selected.

To move the cursor from function to function at the entered X value, press **[▲]** or **[▼]**. To restore the free-moving cursor, press **[◀]** or **[▶]**.

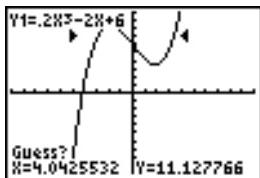
zero

zero finds a zero (x-intercept or root) of a function using **solve(**). Functions can have more than one x-intercept value; **zero** finds the zero closest to your guess.

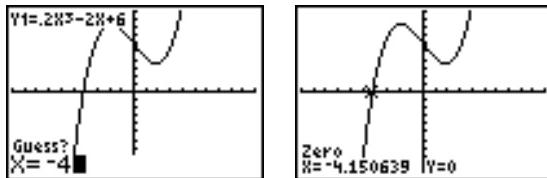
The time **zero** spends to find the correct zero value depends on the accuracy of the values you specify for the left and right bounds and the accuracy of your guess.

To find a zero of a function, follow these steps.

1. Select **2:zero** from the **CALCULATE** menu. The current graph is displayed with **Left Bound?** in the bottom-left corner.
2. Press **▲** or **▼** to move the cursor onto the function for which you want to find a zero.
3. Press **◀** or **▶** (or enter a value) to select the x-value for the left bound of the interval, and then press **ENTER**. A **▶** indicator on the graph screen shows the left bound. **Right Bound?** is displayed in the bottom-left corner. Press **◀** or **▶** (or enter a value) to select the x-value for the right bound, and then press **ENTER**. A **◀** indicator on the graph screen shows the right bound. **Guess?** is then displayed in the bottom-left corner.



4. Press \blacktriangleleft or \triangleright (or enter a value) to select a point near the zero of the function, between the bounds, and then press **ENTER**.



The cursor is on the solution and the coordinates are displayed, even if **CoordOff** format is selected. To move to the same x-value for other selected functions, press \blacktriangleup or \blacktriangledown . To restore the free-moving cursor, press \blacktriangleleft or \triangleright .

minimum, maximum

minimum and **maximum** find a minimum or maximum of a function within a specified interval to a tolerance of 1E-5.

To find a minimum or maximum, follow these steps.

1. Select **3:minimum** or **4:maximum** from the **CALCULATE** menu. The current graph is displayed.
2. Select the function and set left bound, right bound, and guess as described for **zero**.

The cursor is on the solution, and the coordinates are displayed, even if you have selected **CoordOff** format; **Minimum** or **Maximum** is displayed in the bottom-left corner.

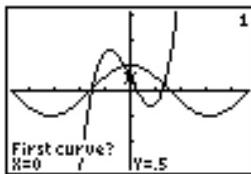
To move to the same x-value for other selected functions, press \blacktriangleleft or \triangleright . To restore the free-moving cursor, press \blacktriangleleft or \triangleright .

intersect

intersect finds the coordinates of a point at which two or more functions intersect using **solve(**. The intersection must appear on the display to use **intersect**.

To find an intersection, follow these steps.

1. Select **5:intersect** from the **CALCULATE** menu. The current graph is displayed with **First curve?** in the bottom-left corner.



2. Press \blacktriangleleft or \triangleright , if necessary, to move the cursor to the first function, and then press **[ENTER]**. **Second curve?** is displayed in the bottom-left corner.

3. Press $\boxed{\square}$ or $\boxed{\triangle}$, if necessary, to move the cursor to the second function, and then press $\boxed{\text{ENTER}}$.
4. Press $\boxed{\triangleright}$ or $\boxed{\triangleleft}$ to move the cursor to the point that is your guess as to location of the intersection, and then press $\boxed{\text{ENTER}}$.

The cursor is on the solution and the coordinates are displayed, even if **CoordOff** format is selected. **Intersection** is displayed in the bottom-left corner. To restore the free-moving cursor, press $\boxed{\triangleleft}$, $\boxed{\triangleup}$, $\boxed{\triangleright}$, or $\boxed{\square}$.

dy/dx

dy/dx (numerical derivative) finds the numerical derivative (slope) of a function at a point, with $\epsilon=1\text{E}-3$.

To find a function's slope at a point, follow these steps.

1. Select **6:dy/dx** from the **CALCULATE** menu. The current graph is displayed.
2. Press $\boxed{\triangleleft}$ or $\boxed{\triangleright}$ to select the function for which you want to find the numerical derivative.
3. Press $\boxed{\triangleleft}$ or $\boxed{\triangleright}$ (or enter a value) to select the **X** value at which to calculate the derivative, and then press $\boxed{\text{ENTER}}$.

The cursor is on the solution and the numerical derivative is displayed.

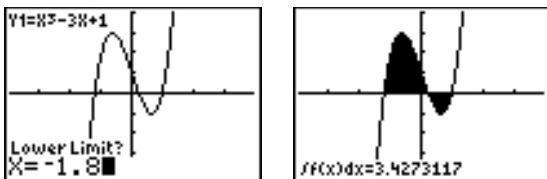
To move to the same x-value for other selected functions, press \blacktriangleleft or \triangleright .
To restore the free-moving cursor, press \blacktriangleleft or \triangleright .

$\int f(x)dx$

$\int f(x)dx$ (numerical integral) finds the numerical integral of a function in a specified interval. It uses the **fInt(** function, with a tolerance of $\epsilon=1E-3$.

To find the numerical derivative of a function, follow these steps.

1. Select 7: $\int f(x)dx$ from the **CALCULATE** menu. The current graph is displayed with **Lower Limit?** in the bottom-left corner.
2. Press \blacktriangleleft or \triangleright to move the cursor to the function for which you want to calculate the integral.
3. Set lower and upper limits as you would set left and right bounds for **zero**. The integral value is displayed, and the integrated area is shaded.



Note: The shaded area is a drawing. Use **ClrDraw** (Chapter 8) or any action that invokes Smart Graph to clear the shaded area.

Chapter 4: **Parametric Graphing**

Getting Started: Path of a Ball

Getting Started is a fast-paced introduction. Read the chapter for details.

Graph the parametric equation that describes the path of a ball hit at an initial speed of 30 meters per second, at an initial angle of 25 degrees with the horizontal from ground level. How far does the ball travel? When does it hit the ground? How high does it go? Ignore all forces except gravity.

For initial velocity v_0 and angle θ , the position of the ball as a function of time has horizontal and vertical components.

$$\text{Horizontal: } X1(t) = v_0 \cos(\theta) \quad \text{Vertical: } Y1(t) = v_0 \sin(\theta) - \frac{1}{2} gt^2$$

The vertical and horizontal vectors of the ball's motion also will be graphed.

| | | |
|--------------------|-------------------------|---------------|
| Vertical vector: | $X2(t)=0$ | $Y2(t)=Y1(t)$ |
| Horizontal vector: | $X3(t)=X1(t)$ | $Y3(t)=0$ |
| Gravity constant: | $g=9.8 \text{ m/sec}^2$ | |

1. Press **MODE**. Press $\boxed{\square}$ $\boxed{\square}$ $\boxed{\square}$ $\boxed{\triangleright}$ **ENTER** to select **Par** mode. Press $\boxed{\square}$ $\boxed{\square}$ $\boxed{\triangleright}$ **ENTER** to select **Simul** for simultaneous graphing of all three parametric equations in this example.

```
Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^<i
Full Horiz G-T
```

2. Press **Y=**. Press **30** $\boxed{X,T,\Theta,n}$ **COS** **25** **2nd** [ANGLE] **1** (to select $^\circ$) $\boxed{\square}$ **ENTER** to define X_1T in terms of T .
3. Press **30** $\boxed{X,T,\Theta,n}$ **SIN** **25** **2nd** [ANGLE] **1** $\boxed{\square}$ $\boxed{-} 9.8$ $\div 2$ $\boxed{X,T,\Theta,n}$ x^2 **ENTER** to define Y_1T .

```
Plot1 Plot2 Plot3
\mathit{X}_1T \mathbf{30} T \cos(25^\circ)
\mathit{Y}_1T \mathbf{30} T \sin(25^\circ)
-9.8/2T^2
\mathit{X}_2T =
\mathit{Y}_2T =
\mathit{X}_3T =
```

The vertical component vector is defined by X_2T and Y_2T .

4. Press **0** **ENTER** to define X_2T .
5. Press **VARS** $\boxed{\triangleright}$ to display the **VARS Y-VARS** menu. Press **2** to display the **PARAMETRIC** secondary menu. Press **2** **ENTER** to define Y_2T .

```
Plot1 Plot2 Plot3
\mathit{X}_1T \mathbf{30} T \cos(25^\circ)
\mathit{Y}_1T \mathbf{30} T \sin(25^\circ)
-9.8/2T^2
\mathit{X}_2T =0
\mathit{Y}_2T =
\mathit{X}_3T =
```

```
Plot1 Plot2 Plot3
\mathit{X}_1T \mathbf{30} T \cos(25^\circ)
\mathit{Y}_1T \mathbf{30} T \sin(25^\circ)
-9.8/2T^2
\mathit{X}_2T =0
\mathit{Y}_2T \mathbf{Y}_1T
\mathit{X}_3T =
```

The horizontal component vector is defined by \mathbf{X}_3T and \mathbf{Y}_3T .

6. Press **VARS** ▶ 2, and then press 1 **ENTER** to define \mathbf{X}_3T . Press 0 **ENTER** to define \mathbf{Y}_3T .
7. Press **◀ ▶ ▲** **ENTER** to change the graph style to \setminus for \mathbf{X}_3T and \mathbf{Y}_3T . Press **▲** **ENTER** **ENTER** to change the graph style to \setminus for \mathbf{X}_2T and \mathbf{Y}_2T . Press **▲** **ENTER** **ENTER** to change the graph style to \setminus for \mathbf{X}_1T and \mathbf{Y}_1T . (These keystrokes assume that all graph styles were set to \setminus originally.)

8. Press **WINDOW**. Enter these values for the window variables.

| | | |
|----------------------|---------------------|---------------------|
| $T_{\min}=0$ | $X_{\min}=-10$ | $Y_{\min}=-5$ |
| $T_{\max}=5$ | $X_{\max}=100$ | $Y_{\max}=15$ |
| $T_{\text{step}}=.1$ | $X_{\text{scl}}=50$ | $Y_{\text{scl}}=10$ |

9. Press **2nd** [FORMAT] ▾ ▾ ▾ ▶ **ENTER** to set **AxesOff**, which turns off the axes.

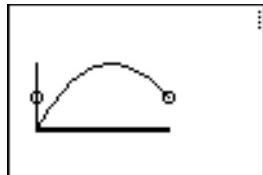
| | | |
|---|-------|-------|
| Plot1 | Plot2 | Plot3 |
| $\mathbf{Y}_1T \setminus 30T \sin(25^\circ)$ | | |
| -9.8/2T^2 | | |
| $\setminus \mathbf{X}_2T \setminus 0$ | | |
| $\mathbf{Y}_2T \setminus \mathbf{Y}_1T$ | | |
| $\setminus \mathbf{X}_3T \setminus \mathbf{X}_1T$ | | |
| $\mathbf{Y}_3T \setminus 0$ | | |
| $\setminus \mathbf{X}_4T =$ | | |

| | | |
|--|-------|-------|
| Plot1 | Plot2 | Plot3 |
| $\setminus \mathbf{X}_1T \setminus 30T \cos(25^\circ)$ | | |
| -9.8/2T^2 | | |
| $\mathbf{Y}_2T \setminus \mathbf{Y}_1T$ | | |
| $\setminus \mathbf{X}_3T \setminus \mathbf{X}_1T$ | | |

| | |
|-------------------------------|--|
| WINDOW | |
| $\uparrow T_{\text{step}}=.1$ | |
| $X_{\min}=-10$ | |
| $X_{\max}=100$ | |
| $X_{\text{scl}}=50$ | |
| $Y_{\min}=-5$ | |
| $Y_{\max}=15$ | |
| $Y_{\text{scl}}=10$ | |

| | |
|----------|----------|
| RectOff | PolarOn |
| CoordOn | CoordOff |
| GridOff | GridOn |
| HxesOff | HxesOn |
| LytesOff | LytesOn |
| LabelOff | LabelOn |
| ExprOn | ExprOff |

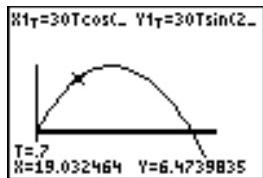
10. Press **GRAPH**. The plotting action simultaneously shows the ball in flight and the vertical and horizontal component vectors of the motion.



Tip: To simulate the ball flying through the air, set graph style to \emptyset (animate) for X_1T and Y_1T .

11. Press **TRACE** to obtain numerical results and answer the questions at the beginning of this section.

Tracing begins at **Tmin** on the first parametric equation (X_1T and Y_1T). As you press **▶** to trace the curve, the cursor follows the path of the ball over time. The values for **X** (distance), **Y** (height), and **T** (time) are displayed at the bottom of the screen.



Defining and Displaying Parametric Graphs

TI-83 Plus Graphing Mode Similarities

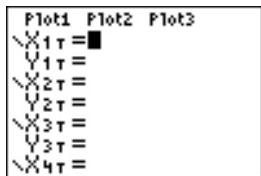
The steps for defining a parametric graph are similar to the steps for defining a function graph. Chapter 4 assumes that you are familiar with Chapter 3: Function Graphing. Chapter 4 details aspects of parametric graphing that differ from function graphing.

Setting Parametric Graphing Mode

To display the mode screen, press **MODE**. To graph parametric equations, you must select **Par** graphing mode before you enter window variables and before you enter the components of parametric equations.

Displaying the Parametric Y= Editor

After selecting **Par** graphing mode, press **Y=** to display the parametric **Y=** editor.



In this editor, you can display and enter both the **X** and **Y** components of up to six equations, **X_{1T}** and **Y_{1T}** through **X_{6T}** and **Y_{6T}**. Each is defined in terms of the independent variable **T**. A common application of parametric graphs is graphing equations over time.

Selecting a Graph Style

The icons to the left of **X_{1T}** through **X_{6T}** represent the graph style of each parametric equation (Chapter 3). The default in **Par** mode is (line), which connects plotted points. Line, (thick), (path), (animate), and (dot) styles are available for parametric graphing.

Defining and Editing Parametric Equations

To define or edit a parametric equation, follow the steps in Chapter 3 for defining a function or editing a function. The independent variable in a parametric equation is **T**. In **Par** graphing mode, you can enter the parametric variable **T** in either of two ways.

- Press **[X,T,θ,n]**.
- Press **[ALPHA] [T]**.

Two components, **X** and **Y**, define a single parametric equation. You must define both of them.

Selecting and Deselecting Parametric Equations

The TI-83 Plus graphs only the selected parametric equations. In the **Y=** editor, a parametric equation is selected when the = signs of both the **X** and **Y** components are highlighted. You may select any or all of the equations **X_{1T}** and **Y_{1T}** through **X_{6T}** and **Y_{6T}**.

To change the selection status, move the cursor onto the = sign of either the **X** or **Y** component and press **ENTER**. The status of both the **X** and **Y** components is changed.

Setting Window Variables

To display the window variable values, press **WINDOW**. These variables define the viewing window. The values below are defaults for **Par** graphing in **Radian** angle mode.

| | |
|--------------------------|---|
| Tmin=0 | Smallest T value to evaluate |
| Tmax=6.2831853... | Largest T value to evaluate (2π) |
| Tstep=.1308996... | T value increment ($\pi/24$) |
| Xmin=-10 | Smallest X value to be displayed |
| Xmax=10 | Largest X value to be displayed |
| Xscl=1 | Spacing between the X tick marks |
| Ymin=-10 | Smallest Y value to be displayed |
| Ymax=10 | Largest Y value to be displayed |
| Yscl=1 | Spacing between the Y tick marks |

Note: To ensure that sufficient points are plotted, you may want to change the **T** window variables.

Setting the Graph Format

To display the current graph format settings, press [2nd] [FORMAT]. Chapter 3 describes the format settings in detail. The other graphing modes share these format settings; **Seq** graphing mode has an additional axes format setting.

Displaying a Graph

When you press [GRAPH], the TI-83 Plus plots the selected parametric equations. It evaluates the **X** and **Y** components for each value of **T** (from **Tmin** to **Tmax** in intervals of **Tstep**), and then plots each point defined by **X** and **Y**. The window variables define the viewing window.

As the graph is plotted, **X**, **Y**, and **T** are updated.

Smart Graph applies to parametric graphs (Chapter 3).

Window Variables and Y-VARS Menus

You can perform these actions from the home screen or a program.

- Access functions by using the name of the **X** or **Y** component of the equation as a variable.

The image shows the TI-83 Plus home screen with the following text displayed in a text box:

X1T=.5
94.70916375

- Store parametric equations.

"sin(T)" \rightarrow X_{1T}
Done
"cos(T)" \rightarrow Y_{1T}
Done

Plot1 Plot2 Plot3
 \checkmark X_{1T}=sin(T)
 \checkmark Y_{1T}=cos(T)
 \checkmark X_{2T}=
 \checkmark Y_{2T}=

- Select or deselect parametric equations.

FnOff 1
Done

Plot1 Plot2 Plot3
 \checkmark X_{1T}=cos(T)
 \checkmark Y_{1T}=sin(T)
 \checkmark X_{2T}=
 \checkmark Y_{2T}=

- Store values directly to window variables.

360 \rightarrow Tmax
360

Exploring Parametric Graphs

Free-Moving Cursor

The free-moving cursor in **Par** graphing works the same as in **Func** graphing.

In **RectGC** format, moving the cursor updates the values of **X** and **Y**; if **CoordOn** format is selected, **X** and **Y** are displayed.

In **PolarGC** format, **X**, **Y**, **R**, and θ are updated; if **CoordOn** format is selected, **R** and θ are displayed.

TRACE

To activate **TRACE**, press **TRACE**. When **TRACE** is active, you can move the trace cursor along the graph of the equation one **Tstep** at a time. When you begin a trace, the trace cursor is on the first selected function at **Tmin**. If **ExprOn** is selected, then the function is displayed.

In **RectGC** format, **TRACE** updates and displays the values of **X**, **Y**, and **T** if **CoordOn** format is on.

In **PolarGC** format, **X**, **Y**, **R**, θ and **T** are updated; if **CoordOn** format is selected, **R**, θ , and **T** are displayed. The **X** and **Y** (or **R** and θ) values are calculated from **T**.

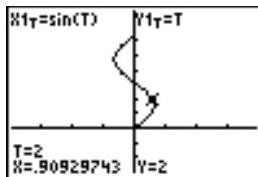
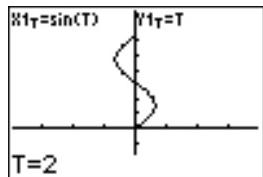
To move five plotted points at a time on a function, press **2nd** **[◀]** or **2nd** **[▶]**. If you move the cursor beyond the top or bottom of the screen, the coordinate values at the bottom of the screen continue to change appropriately.

Quick Zoom is available in **Par** graphing; panning is not (Chapter 3).

Moving the Trace Cursor to Any Valid T Value

To move the trace cursor to any valid **T** value on the current function, enter the number. When you enter the first digit, a **T=** prompt and the number you entered are displayed in the bottom-left corner of the screen. You can enter an expression at the **T=** prompt. The value must be valid for the current viewing window. When you have completed the entry, press **ENTER** to move the cursor.

Plot1 Plot2 Plot3
X_{1T}=sin(T)
Y_{1T}=T



ZOOM

zoom operations in **Par** graphing work the same as in **Func** graphing. Only the **X** (**Xmin**, **Xmax**, and **Xscl**) and **Y** (**Ymin**, **Ymax**, and **Yscl**) window variables are affected.

The **T** window variables (**Tmin**, **Tmax**, and **Tstep**) are only affected when you select **ZStandard**. The **VARS ZOOM** secondary menu **ZT/Z₀** items **1:ZTmin**, **2:ZTmax**, and **3:ZTstep** are the zoom memory variables for **Par** graphing.

CALC

CALC operations in **Par** graphing work the same as in **Func** graphing. The **CALCULATE** menu items available in **Par** graphing are **1:value**, **2:dy/dx**, **3:dy/dt**, and **4:dx/dt**.

Chapter 5: **Polar Graphing**

Getting Started: Polar Rose

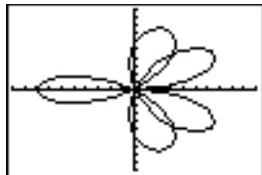
Getting Started is a fast-paced introduction. Read the chapter for details.

The polar equation $R=Asin(B\theta)$ graphs a rose. Graph the rose for $A=8$ and $B=2.5$, and then explore the appearance of the rose for other values of A and B .

1. Press **MODE** to display the mode screen. Press **▼ ▼ ▼ ▶ ▶** **ENTER** to select **Pol** graphing mode. Select the defaults (the options on the left) for the other mode settings.
2. Press **Y=** to display the polar **Y=** editor. Press **8 SIN 2.5 (X,T,Θ,n) □ ENTER** to define **r1**.

```
Plot1 Plot2 Plot3
r1=8sin(2.5θ)
r2=
r3=
r4=
r5=
r6=
```

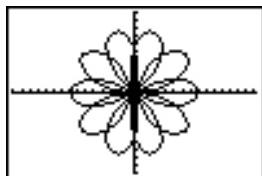
3. Press **ZOOM** 6 to select **6:ZStandard** and graph the equation in the standard viewing window. The graph shows only five petals of the rose, and the rose does not appear to be symmetrical. This is because the standard window sets $\theta_{\text{max}}=2\pi$ and defines the window, rather than the pixels, as square.



4. Press **WINDOW** to display the window variables. Press **▼** 4 **[2nd]** [π] to increase the value of θ_{max} to 4π .

```
WINDOW
θmin=0
θmax=4π
θstep=.1308996...
Xmin=-10
Xmax=10
Xscl=1
↓Ymin=-10
```

5. Press **ZOOM** 5 to select **5:ZSquare** and plot the graph.



6. Repeat steps 2 through 5 with new values for the variables **A** and **B** in the polar equation $r_1=A\sin(B\theta)$. Observe how the new values affect the graph.

Defining and Displaying Polar Graphs

TI-83 Plus Graphing Mode Similarities

The steps for defining a polar graph are similar to the steps for defining a function graph. Chapter 5 assumes that you are familiar with Chapter 3: Function Graphing. Chapter 5 details aspects of polar graphing that differ from function graphing.

Setting Polar Graphing Mode

To display the mode screen, press **MODE**. To graph polar equations, you must select **POL** graphing mode before you enter values for the window variables and before you enter polar equations.

Displaying the Polar Y= Editor

After selecting **POL** graphing mode, press **[Y=]** to display the polar **Y=** editor.

| | | |
|---------|-------|-------|
| Plot1 | Plot2 | Plot3 |
| $r_1 =$ | | |
| $r_2 =$ | | |
| $r_3 =$ | | |
| $r_4 =$ | | |
| $r_5 =$ | | |
| $r_6 =$ | | |

In this editor, you can enter and display up to six polar equations, r_1 through r_6 . Each is defined in terms of the independent variable θ .

Selecting Graph Styles

The icons to the left of r_1 through r_6 represent the graph style of each polar equation (Chapter 3). The default in **Pol** graphing mode is (line), which connects plotted points. Line, (thick), (path), (animate), and (dot) styles are available for polar graphing.

Defining and Editing Polar Equations

To define or edit a polar equation, follow the steps in Chapter 3 for defining a function or editing a function. The independent variable in a polar equation is θ . In **Pol** graphing mode, you can enter the polar variable θ in either of two ways.

- Press **[X,T,θ,n]**.
- Press **[ALPHA]** [θ].

Selecting and Deselecting Polar Equations

The TI-83 Plus graphs only the selected polar equations. In the **Y=** editor, a polar equation is selected when the **=** sign is highlighted. You may select any or all of the equations.

To change the selection status, move the cursor onto the = sign, and then press **[ENTER]**.

Setting Window Variables

To display the window variable values, press **[WINDOW]**. These variables define the viewing window. The values below are defaults for **Pol** graphing in **Radian** angle mode.

| | |
|--------------------------------------|--|
| $\theta_{\text{min}}=0$ | Smallest θ value to evaluate |
| $\theta_{\text{max}}=6.2831853\dots$ | Largest θ value to evaluate (2π) |
| $\theta_{\text{step}}=.1308996\dots$ | Increment between θ values ($\pi/24$) |
| $X_{\text{min}}=-10$ | Smallest X value to be displayed |
| $X_{\text{max}}=10$ | Largest X value to be displayed |
| $X_{\text{scl}}=1$ | Spacing between the X tick marks |
| $Y_{\text{min}}=-10$ | Smallest Y value to be displayed |
| $Y_{\text{max}}=10$ | Largest Y value to be displayed |
| $Y_{\text{scl}}=1$ | Spacing between the Y tick marks |

Note: To ensure that sufficient points are plotted, you may want to change the θ window variables.

Setting the Graph Format

To display the current graph format settings, press **[2nd] [FORMAT]**. Chapter 3 describes the format settings in detail. The other graphing modes share these format settings.

Displaying a Graph

When you press **[GRAPH]**, the TI-83 Plus plots the selected polar equations. It evaluates R for each value of θ (from θ_{min} to θ_{max} in intervals of θ_{step}) and then plots each point. The window variables define the viewing window.

As the graph is plotted, X , Y , R , and θ are updated.

Smart Graph applies to polar graphs (Chapter 3).

Window Variables and Y-VARS Menus

You can perform these actions from the home screen or a program.

- Access functions by using the name of the equation as a variable.



The image shows the TI-83 Plus home screen. A rectangular input field contains the expression "r1+r2". To the right of the input field is a small numeric keypad showing the number "8".

- Store polar equations.

The screen shows the command `"50"→r1` in the input field, with "Done" displayed below it. To the right, the function menu is open with options `Plot1`, `Plot2`, and `Plot3`. Below the menu, the variable `\r1` is highlighted with a box around its value `50`, and `\r2=` is shown below it.

- Select or deselect polar equations.

The screen shows the command `FnOff 1` in the input field, with "Done" displayed below it. To the right, the function menu is open with options `Plot1`, `Plot2`, and `Plot3`. Below the menu, the variable `\r1` is highlighted with a box around its value `50`, indicating it is selected, and `\r2=` is shown below it.

- Store values directly to window variables.

The screen shows the command `0→θmin` in the input field, with "0" displayed in the output field. To the right, the function menu is open with options `Plot1`, `Plot2`, and `Plot3`.

Exploring Polar Graphs

Free-Moving Cursor

The free-moving cursor in **Pol** graphing works the same as in **Func** graphing. In **RectGC** format, moving the cursor updates the values of **X** and **Y**; if **CoordOn** format is selected, **X** and **Y** are displayed. In **PolarGC** format, **X**, **Y**, **R**, and θ are updated; if **CoordOn** format is selected, **R** and θ are displayed.

TRACE

To activate **TRACE**, press **[TRACE]**. When **TRACE** is active, you can move the trace cursor along the graph of the equation one **θstep** at a time. When you begin a trace, the trace cursor is on the first selected function at **θmin**. If **ExprOn** format is selected, then the equation is displayed.

In **RectGC** format, **TRACE** updates the values of **X**, **Y**, and θ ; if **CoordOn** format is selected, **X**, **Y**, and θ are displayed. In **PolarGC** format, **TRACE** updates **X**, **Y**, **R**, and θ ; if **CoordOn** format is selected, **R** and θ are displayed.

To move five plotted points at a time on a function, press **[2nd] [Left Arrow]** or **[2nd] [Right Arrow]**. If you move the trace cursor beyond the top or bottom of the

screen, the coordinate values at the bottom of the screen continue to change appropriately.

Quick Zoom is available in **POL** graphing mode; panning is not (Chapter 3).

Moving the Trace Cursor to Any Valid θ Value

To move the trace cursor to any valid θ value on the current function, enter the number. When you enter the first digit, a $\theta=$ prompt and the number you entered are displayed in the bottom-left corner of the screen. You can enter an expression at the $\theta=$ prompt. The value must be valid for the current viewing window. When you complete the entry, press **[ENTER]** to move the cursor.

ZOOM

zoom operations in **POL** graphing work the same as in **Func** graphing. Only the **X** (**Xmin**, **Xmax**, and **Xscl**) and **Y** (**Ymin**, **Ymax**, and **Yscl**) window variables are affected.

The θ window variables (**θ_{min}** , **θ_{max}** , and **θ_{step}**) are not affected, except when you select **ZStandard**. The **VARS ZOOM** secondary menu **ZT/Z θ** items **4:Z θ_{min}** , **5:Z θ_{max}** , and **6:Z θ_{step}** are zoom memory variables for **POL** graphing.

CALC

CALC operations in **Pol** graphing work the same as in **Func** graphing. The **CALCULATE** menu items available in **Pol** graphing are **1:value**, **2:dy/dx**, and **3:dr/dθ**.

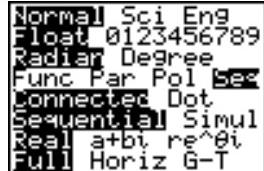
Chapter 6: **Sequence Graphing**

Getting Started: Forest and Trees

Getting Started is a fast-paced introduction. Read the chapter for details.

A small forest of 4,000 trees is under a new forestry plan. Each year 20 percent of the trees will be harvested and 1,000 new trees will be planted. Will the forest eventually disappear? Will the forest size stabilize? If so, in how many years and with how many trees?

1. Press **MODE**. Press **ENTER** to select **Seq** graphing mode.



Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol **Seq**
Connected Dot
Sequential Simul
Real a+bi re^ei
Full Horiz G-T

2. Press **2nd** **[FORMAT]** and select **Time** axes format and **ExprOn** format if necessary.



TimeWeb uv vw uw
RectOff PolarGC
CoordOn CoordOff
GridOff GridOn
AxesOff AxesOn
LabelOff LabelOn
ExprOn ExprOff

- Press **[Y=]**. If the graph-style icon is not \cdot (dot), press **[\blacktriangleleft] [\blacktriangleright]**, press **[ENTER]** until \cdot is displayed, and then press **[\blacktriangleright] [\blacktriangleright]**.
- Press **MATH** **[\blacktriangleright]** **3** to select **iPart(** (integer part) because only whole trees are harvested. After each annual harvest, 80 percent (.80) of the trees remain.

Press **[.]** **8 [2nd]** **[u]** **[\square]** **[X,T, Θ ,n]** **[\square]** **-** **1 [)** to define the number of trees after each harvest. Press **[+]** **1000 [)** to define the new trees. Press **[\square]** **4000** to define the number of trees at the beginning of the program.

- Press **[WINDOW]** **0** to set **nMin=0**. Press **[\square]** **50** to set **nMax=50**. **nMin** and **nMax** evaluate forest size over 50 years. Set the other window variables.

PlotStart=1

Xmin=0

Ymin=0

PlotStep=1

Xmax=50

Ymax=6000

Xscl=10

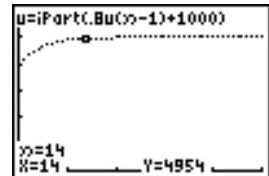
Yscl=1000

```

Plot1 Plot2 Plot3
nMin=1
·u(n)·iPart(.8u(n-1)+1000)
·u(nMin)=4000
·v(n)=
v(nMin)=
·w(n)=

```

6. Press **TRACE**. Tracing begins at $nMin$ (the start of the forestry plan). Press **►** to trace the sequence year by year. The sequence is displayed at the top of the screen. The values for n (number of years), X ($X=n$, because n is plotted on the x-axis), and Y (tree count) are displayed at the bottom. When will the forest stabilize? With how many trees?



Defining and Displaying Sequence Graphs

TI-83 Plus Graphing Mode Similarities

The steps for defining a sequence graph are similar to the steps for defining a function graph. Chapter 6 assumes that you are familiar with Chapter 3: Function Graphing. Chapter 6 details aspects of sequence graphing that differ from function graphing.

Setting Sequence Graphing Mode

To display the mode screen, press **MODE**. To graph sequence functions, you must select **Seq** graphing mode before you enter window variables and before you enter sequence functions.

Sequence graphs automatically plot in **Simul** mode, regardless of the current plotting-order mode setting.

TI-83 Plus Sequence Functions u, v, and w

The TI-83 Plus has three sequence functions that you can enter from the keyboard: **u**, **v**, and **w**. They are above the **[7]**, **[8]**, and **[9]** keys.

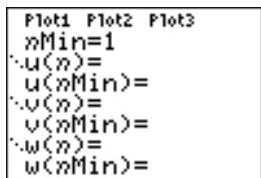
You can define sequence functions in terms of:

- The independent variable n
- The previous term in the sequence function, such as $u(n-1)$
- The term that precedes the previous term in the sequence function, such as $u(n-2)$
- The previous term or the term that precedes the previous term in another sequence function, such as $u(n-1)$ or $u(n-2)$ referenced in the sequence $v(n)$.

Note: Statements in this chapter about $u(n)$ are also true for $v(n)$ and $w(n)$; statements about $u(n-1)$ are also true for $v(n-1)$ and $w(n-1)$; statements about $u(n-2)$ are also true for $v(n-2)$ and $w(n-2)$.

Displaying the Sequence Y= Editor

After selecting **Seq** mode, press **[Y=]** to display the sequence **Y=** editor.



```
Plot1 Plot2 Plot3
nMin=1
·u(n)=
u(nMin)=
·v(n)=
v(nMin)=
·w(n)=
w(nMin)=
```

In this editor, you can display and enter sequences for $u(n)$, $v(n)$, and $w(n)$. Also, you can edit the value for $nMin$, which is the sequence window variable that defines the minimum n value to evaluate.

The sequence **Y=** editor displays the **nMin** value because of its relevance to **u(nMin)**, **v(nMin)**, and **w(nMin)**, which are the initial values for the sequence equations **u(n)**, **v(n)**, and **w(n)**, respectively.

nMin in the **Y=** editor is the same as **nMin** in the window editor. If you enter a new value for **nMin** in one editor, the new value for **nMin** is updated in both editors.

Note: Use **u(nMin)**, **v(nMin)**, or **w(nMin)** only with a recursive sequence, which requires an initial value.

Selecting Graph Styles

The icons to the left of **u(n)**, **v(n)**, and **w(n)** represent the graph style of each sequence (Chapter 3). The default in **Seq** mode is **.** (dot), which shows discrete values. **.**, **** (line), and **■** (thick) styles are available for sequence graphing. Graph styles are ignored in **Web** format.

Selecting and Deselecting Sequence Functions

The TI-83 Plus graphs only the selected sequence functions. In the **Y=** editor, a sequence function is selected when the **=** signs of both **u(n)=** and **u(nMin)=** are highlighted.

To change the selection status of a sequence function, move the cursor onto the **=** sign of the function name, and then press **[ENTER]**. The status is changed for both the sequence function **u(n)** and its initial value **u(nMin)**.

Defining and Editing a Sequence Function

To define or edit a sequence function, follow the steps in Chapter 3 for defining a function. The independent variable in a sequence is n .

In **Seq** graphing mode, you can enter the sequence variable in either of two ways.

- Press **[X,T,Θ,n]**.
- Press **[2nd] [CATALOG] [N]**.

You can enter the function name from the keyboard.

- To enter the function name **u**, press **[2nd] [u]** (above **7**).
- To enter the function name **v**, press **[2nd] [v]** (above **8**).
- To enter the function name **w**, press **[2nd] [w]** (above **9**).

Generally, sequences are either nonrecursive or recursive. Sequences are evaluated only at consecutive integer values. n is always a series of consecutive integers, starting at zero or any positive integer.

Nonrecursive Sequences

In a nonrecursive sequence, the n th term is a function of the independent variable n . Each term is independent of all other terms.

For example, in the nonrecursive sequence below, you can calculate $u(5)$ directly, without first calculating $u(1)$ or any previous term.

```
Plot1 Plot2 Plot3  
nMin=1  
.u(n)=2*n  
u(nMin)=  
.v(n)=  
v(nMin)=  
.w(n)=  
w(nMin)=
```

The sequence equation above returns the sequence **2, 4, 6, 8, 10, ...** for $n = 1, 2, 3, 4, 5, \dots$.

Note: You may leave blank the initial value $u(nMin)$ when calculating nonrecursive sequences.

Recursive Sequences

In a recursive sequence, the n th term in the sequence is defined in relation to the previous term or the term that precedes the previous term, represented by $u(n-1)$ and $u(n-2)$. A recursive sequence may also be defined in relation to n , as in $u(n)=u(n-1)+n$.

For example, in the sequence below you cannot calculate $u(5)$ without first calculating $u(1)$, $u(2)$, $u(3)$, and $u(4)$.

```
Plot1 Plot2 Plot3  
nMin=1  
.u(n)=2*u(n-1)  
u(nMin)=1
```

Using an initial value $u(n_{\text{Min}}) = 1$, the sequence above returns
1, 2, 4, 8, 16, ...

Tip: On the TI-83 Plus, you must type each character of the terms. For example, to enter $u(n-1)$, press **2nd [u] (X,T,θ,n) - [1] ()**.

Recursive sequences require an initial value or values, since they reference undefined terms.

- If each term in the sequence is defined in relation to the previous term, as in $u(n-1)$, you must specify an initial value for the first term.

```
Plot1 Plot2 Plot3
nMin=1
:u(n)·.8u(n-1)+5
0
u(nMin)·100
```

- If each term in the sequence is defined in relation to the term that precedes the previous term, as in $u(n-2)$, you must specify initial values for the first two terms. Enter the initial values as a list enclosed in braces $\{ \}$ with commas separating the values.

```
Plot1 Plot2 Plot3
nMin=1
:u(n)·u(n-1)+u(n
-2)
u(nMin)·{1,0}
```

The value of the first term is 0 and the value of the second term is 1 for the sequence $u(n)$.

Setting Window Variables

To display the window variables, press **WINDOW**. These variables define the viewing window. The values below are defaults for **Seq** graphing in both **Radian** and **Degree** angle modes.

| | |
|---------------|---|
| $nMin=1$ | Smallest n value to evaluate |
| $nMax=10$ | Largest n value to evaluate |
| $PlotStart=1$ | First term number to be plotted |
| $PlotStep=1$ | Incremental n value (for graphing only) |
| $Xmin=-10$ | Smallest X value to be displayed |
| $Xmax=10$ | Largest X value to be displayed |
| $Xscl=1$ | Spacing between the X tick marks |
| $Ymin=-10$ | Smallest Y value to be displayed |
| $Ymax=10$ | Largest Y value to be displayed |
| $Yscl=1$ | Spacing between the Y tick marks |

$nMin$ must be an integer ≥ 0 . **$nMax$** , **PlotStart**, and **PlotStep** must be integers ≥ 1 .

$nMin$ is the smallest n value to evaluate. **$nMin$** also is displayed in the sequence **Y=** editor. **$nMax$** is the largest n value to evaluate. Sequences are evaluated at $u(nMin)$, $u(nMin+1)$, $u(nMin+2)$, . . . , $u(nMax)$.

PlotStart is the first term to be plotted. **PlotStart=1** begins plotting on the first term in the sequence. If you want plotting to begin with the fifth term in a sequence, for example, set **PlotStart=5**. The first four terms are evaluated but are not plotted on the graph.

PlotStep is the incremental *n* value for graphing only. **PlotStep** does not affect sequence evaluation; it only designates which points are plotted on the graph. If you specify **PlotStep=2**, the sequence is evaluated at each consecutive integer, but it is plotted on the graph only at every other integer.

Selecting Axes Combinations

Setting the Graph Format

To display the current graph format settings, press [2nd] [FORMAT]. Chapter 3 describes the format settings in detail. The other graphing modes share these format settings. The axes setting on the top line of the screen is available only in **Seq** mode.

| | | |
|----------|--------------|----------------------------------|
| Time | Web uv vw uw | Type of sequence plot (axes) |
| RectGC | PolarGC | Rectangular or polar output |
| CoordOn | CoordOff | Cursor coordinate display on/off |
| GridOff | GridOn | Grid display off or on |
| AxesOn | AxesOff | Axes display on or off |
| LabelOff | LabelOn | Axes label display off or on |
| ExprOn | ExprOff | Expression display on or off |

Setting Axes Format

For sequence graphing, you can select from five axes formats. The table below shows the values that are plotted on the x-axis and y-axis for each axes setting.

| Axes Setting | x-axis | y-axis |
|--------------|--------------------------------|--------------------------|
| Time | n | $u(n)$, $v(n)$, $w(n)$ |
| <u>Web</u> | $u(n-1)$, $v(n-1)$, $w(n-1)$ | $u(n)$, $v(n)$, $w(n)$ |
| <u>uv</u> | $u(n)$ | $v(n)$ |
| <u>vw</u> | $v(n)$ | $w(n)$ |
| <u>uw</u> | $u(n)$ | $w(n)$ |

Displaying a Sequence Graph

To plot the selected sequence functions, press **[GRAPH]**. As a graph is plotted, the TI-83 Plus updates **X**, **Y**, and **n**.

Smart Graph applies to sequence graphs (Chapter 3).

Exploring Sequence Graphs

Free-Moving Cursor

The free-moving cursor in **Seq** graphing works the same as in **Func** graphing. In **RectGC** format, moving the cursor updates the values of **X** and **Y**; if **CoordOn** format is selected, **X** and **Y** are displayed. In **PolarGC** format, **X**, **Y**, **R**, and θ are updated; if **CoordOn** format is selected, **R** and θ are displayed.

TRACE

The axes format setting affects **TRACE**.

When **Time**, **uv**, **vw**, or **uw** axes format is selected, **TRACE** moves the cursor along the sequence one **PlotStep** increment at a time. To move five plotted points at once, press **2nd** **▶** or **2nd** **◀**.

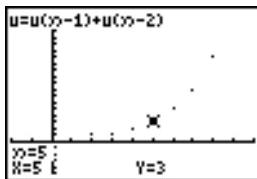
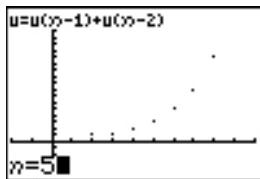
- When you begin a trace, the trace cursor is on the first selected sequence at the term number specified by **PlotStart**, even if it is outside the viewing window.
- Quick Zoom applies to all directions. To center the viewing window on the current cursor location after you have moved the trace cursor, press **ENTER**. The trace cursor returns to **nMin**.

In **Web** format, the trail of the cursor helps identify points with attracting and repelling behavior in the sequence. When you begin a trace, the cursor is on the x-axis at the initial value of the first selected function.

Tip: To move the cursor to a specified n during a trace, enter a value for n , and press **ENTER**. For example, to quickly return the cursor to the beginning of the sequence, paste $nMin$ to the $n=$ prompt and press **ENTER**.

Moving the Trace Cursor to Any Valid n Value

To move the trace cursor to any valid n value on the current function, enter the number. When you enter the first digit, an $n =$ prompt and the number you entered are displayed in the bottom-left corner of the screen. You can enter an expression at the $n =$ prompt. The value must be valid for the current viewing window. When you have completed the entry, press **ENTER** to move the cursor.



ZOOM

zoom operations in **Seq** graphing work the same as in **Func** graphing. Only the **X** (**Xmin**, **Xmax**, and **Xscl**) and **Y** (**Ymin**, **Ymax**, and **Yscl**) window variables are affected.

PlotStart, **PlotStep**, **nMin**, and **nMax** are only affected when you select **ZStandard**. The **VARS** **Zoom** secondary menu **zu** items 1 through 7 are the **ZOOM MEMORY** variables for **Seq** graphing.

CALC

The only **CALC** operation available in **Seq** graphing is **value**.

- When **Time** axes format is selected, **value** displays **Y** (the **u(n)** value) for a specified **n** value.
- When **Web** axes format is selected, **value** draws the web and displays **Y** (the **u(n)** value) for a specified **n** value.
- When **uv**, **vw**, or **uw** axes format is selected, **value** displays **X** and **Y** according to the axes format setting. For example, for **uv** axes format, **X** represents **u(n)** and **Y** represents **v(n)**.

Evaluating u, v, and w

To enter the sequence names u, v, or w, press [2nd] [u], [v], or [w]. You can evaluate these names in any of three ways.

- Calculate the nth value in a sequence.
- Calculate a list of values in a sequence.
- Generate a sequence with **u(*nstart,nstop[,nstep]*)**. *nstep* is optional; default is 1.

```
"n²"→u:u(3)      9  
u({1,3,5,7,9})  
{1 9 25 49 81}  
u(1,9,2)  
{1 9 25 49 81}
```

Graphing Web Plots

Graphing a Web Plot

To select **Web** axes format, press **2nd** [FORMAT] **▶** **[ENTER]**. A web plot graphs $u(n)$ versus $u(n-1)$, which you can use to study long-term behavior (convergence, divergence, or oscillation) of a recursive sequence. You can see how the sequence may change behavior as its initial value changes.

Valid Functions for Web Plots

When **Web** axes format is selected, a sequence will not graph properly or will generate an error.

- It must be recursive with only one recursion level ($u(n-1)$ but not $u(n-2)$).
- It cannot reference n directly.
- It cannot reference any defined sequence except itself.

Displaying the Graph Screen

In **Web** format, press **[GRAPH]** to display the graph screen. The TI-83 Plus:

- Draws a $y=x$ reference line in **AxesOn** format.
- Plots the selected sequences with $u(n-1)$ as the independent variable.

Note: A potential convergence point occurs whenever a sequence intersects the $y=x$ reference line. However, the sequence may or may not actually converge at that point, depending on the sequence's initial value.

Drawing the Web

To activate the trace cursor, press **[TRACE]**. The screen displays the sequence and the current n , X , and Y values (X represents $u(n-1)$ and Y represents $u(n)$). Press **[▶]** repeatedly to draw the web step by step, starting at $nMin$. In **Web** format, the trace cursor follows this course.

1. It starts on the x -axis at the initial value $u(nMin)$ (when **PlotStart=1**).
2. It moves vertically (up or down) to the sequence.
3. It moves horizontally to the $y=x$ reference line.
4. It repeats this vertical and horizontal movement as you continue to press **[▶]**.

Using Web Plots to Illustrate Convergence

Example: Convergence

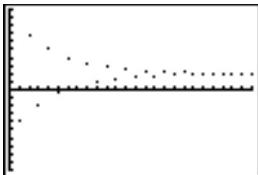
1. Press **[Y=]** in **Seq** mode to display the sequence **Y=** editor. Make sure the graph style is set to **.** (dot), and then define **nMin**, **u(n)** and **u(nMin)** as shown below.

```
Plot1 Plot2 Plot3
nMin=1
·u(n)=.8u(n-1)+3.6
·u(nMin)=-4
·v(n)=
v(nMin)=
·w(n)=
```

2. Press **[2nd] [FORMAT]** **[ENTER]** to set **Time** axes format.
3. Press **[WINDOW]** and set the variables as shown below.

| | | |
|--------------------|----------------|-----------------|
| nMin=1 | Xmin=0 | Ymin=-10 |
| nMax=25 | Xmax=25 | Ymax=10 |
| PlotStart=1 | Xscl=1 | Yscl=1 |
| PlotStep=1 | | |

4. Press **[GRAPH]** to graph the sequence.



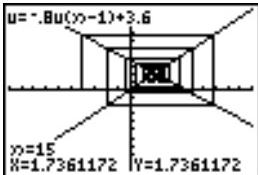
5. Press **[2nd] [FORMAT]** and select the **Web** axes setting.

6. Press **[WINDOW]** and change the variables below.

Xmin=-10 Xmax=10

7. Press **[GRAPH]** to graph the sequence.

8. Press **[TRACE]**, and then press **[▼]** to draw the web. The displayed cursor coordinates **n**, **X (u(n-1))**, and **Y (u(n))** change accordingly. When you press **[▼]**, a new **n** value is displayed, and the trace cursor is on the sequence. When you press **[▼]** again, the **n** value remains the same, and the cursor moves to the **y=x** reference line. This pattern repeats as you trace the web.



Graphing Phase Plots

Graphing with uv, vw, and uw

The phase-plot axes settings **uv**, **vw**, and **uw** show relationships between two sequences. To select a phase-plot axes setting, press [2nd] [FORMAT], press **▶** until the cursor is on **uv**, **vw**, or **uw**, and then press **ENTER**.

| Axes Setting | x-axis | y-axis |
|--------------|--------|--------|
| uv | $u(n)$ | $v(n)$ |
| vw | $v(n)$ | $w(n)$ |
| uw | $u(n)$ | $w(n)$ |

Example: Predator-Prey Model

Use the predator-prey model to determine the regional populations of a predator and its prey that would maintain population equilibrium for the two species.

This example uses the model to determine the equilibrium populations of foxes and rabbits, with initial populations of 200 rabbits ($u(nMin)$) and 50 foxes ($v(nMin)$).

These are the variables (given values are in parentheses):

R = number of rabbits

M = rabbit population growth rate without foxes (.05)

K = rabbit population death rate with foxes (.001)

W = number of foxes

G = fox population growth rate with rabbits (.0002)

D = fox population death rate without rabbits (.03)

n = time (in months)

$$R_n = R_{n-1}(1+M-KW_{n-1})$$

$$W_n = W_{n-1}(1+GR_{n-1}-D)$$

1. Press **[Y=]** in **Seq** mode to display the sequence **Y=** editor. Define the sequences and initial values for R_n and W_n as shown below. Enter the sequence R_n as $u(n)$ and enter the sequence W_n as $v(n)$.

```
Plot1 Plot2 Plot3
nMin=1
·u(n)·u(n-1)*(1+
.05-.001*v(n-1))
u(nMin)=200
·v(n)·v(n-1)*(1+
.0002*u(n-1)-.03)
>
v(nMin)=50
·w(n)=
w(nMin)=
```

2. Press **[2nd]** **[FORMAT]** **[ENTER]** to select **Time** axes format.

3. Press **WINDOW** and set the variables as shown below.

nMin=0

Xmin=0

Ymin=0

nMax=400

Xmax=400

Ymax=300

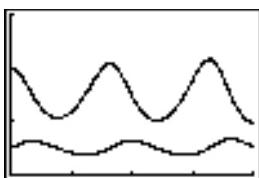
PlotStart=1

Xscl=100

Yscl=100

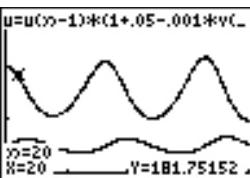
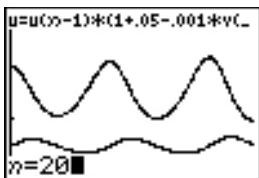
PlotStep=1

4. Press **GRAPH** to graph the sequence.



5. Press **TRACE** **▶** to individually trace the number of rabbits ($u(n)$) and foxes ($v(n)$) over time (n).

Tip: Press a number, and then press **ENTER** to jump to a specific n value (month) while in **TRACE**.



6. Press **2nd** **[FORMAT]** **▶** **▶** **ENTER** to select **uv** axes format.

7. Press **WINDOW** and change these variables as shown below.

Xmin=84

Ymin=25

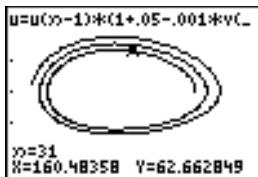
Xmax=237

Ymax=75

Xscl=50

Yscl=10

8. Press **TRACE**. Trace both the number of rabbits (**X**) and the number of foxes (**Y**) through 400 generations.



Note: When you press **TRACE**, the equation for **u** is displayed in the top-left corner. Press **▲** or **▼** to see the equation for **v**.

Comparing TI-83 Plus and TI-82 Sequence Variables

Sequences and Window Variables

Refer to the table if you are familiar with the TI-82. It shows TI-83 Plus sequences and sequence window variables, as well as their TI-82 counterparts.

| TI-83 Plus | TI-82 |
|--------------------------|----------------------------------|
| In the Y= editor: | |
| u(n) | Un |
| u(nMin) | UnStart (window variable) |
| v(n) | Vn |
| v(nMin) | VnStart (window variable) |
| w(n) | not available |
| w(nMin) | not available |
| In the window editor: | |
| nMin | nStart |
| nMax | nMax |
| PlotStart | nMin |
| PlotStep | not available |

Keystroke Differences Between TI-83 Plus and TI-82

Sequence Keystroke Changes

Refer to the table if you are familiar with the TI-82. It compares TI-83 Plus sequence-name syntax and variable syntax with TI-82 sequence-name syntax and variable syntax.

| TI-83 Plus / TI-82 | On TI-83 Plus, press: | On TI-82, press: |
|----------------------|----------------------------------|---------------------|
| n / n | [X,T,Θ,n] | [2nd] [n] |
| $u(n)$ / U_n | [2nd] [u] ([X,T,Θ,n]) | [2nd] [Y-VARS] 4 1 |
| $v(n)$ / V_n | [2nd] [v] ([X,T,Θ,n]) | [2nd] [Y-VARS] 4 2 |
| $w(n)$ | [2nd] [w] ([X,T,Θ,n]) | not available |
| $u(n-1)$ / U_{n-1} | [2nd] [u] ([X,T,Θ,n] - 1) | [2nd] [U_{n-1}] |
| $v(n-1)$ / V_{n-1} | [2nd] [v] ([X,T,Θ,n] - 1) | [2nd] [V_{n-1}] |
| $w(n-1)$ | [2nd] [w] ([X,T,Θ,n] - 1) | not available |

Chapter 7: **Tables**

Getting Started: Roots of a Function

Getting Started is a fast-paced introduction. Read the chapter for details.

Evaluate the function $Y = X^3 - 2X$ at each integer between -10 and 10. How many sign changes occur, and at what X values?

1. Press **MODE** **▼** **▼** **▼** **ENTER** to set **Func** graphing mode.
2. Press **[Y=]**. Press **[X,T,Θ,n]** **MATH** **3** to select **3^{rd}** . Then press **[−]** **2** **[X,T,Θ,n]** to enter the function $Y_1=X^3-2X$.
3. Press **2nd** **[TBLSET]** to display the **TABLE SETUP** screen. Press **[−]** **10** **ENTER** to set **TblStart=-10**. Press **1** **ENTER** to set **$\Delta Tbl=1$** .

```
Plot1 Plot2 Plot3
\Y1=X^3-2X
\Y2=
\Y3=
\Y4=
\Y5=
\Y6=
\Y7=
```

```
TABLE SETUP
TblStart=-10
ΔTbl=1
IndPnt: Auto Ask
Depend: Auto Ask
```

Press **[ENTER]** to select **Indpnt: Auto**
(automatically generated independent values).

Press **[▼]** **[ENTER]** to select **Depend: Auto**
(automatically generated dependent values).

4. Press **[2nd]** **[TABLE]** to display the table screen.

| X | Y1 |
|-----|------|
| -10 | -980 |
| -9 | -711 |
| -8 | -496 |
| -7 | -329 |
| -6 | -204 |
| -5 | -115 |
| -4 | -56 |

X = -10

5. Press **[▼]** until you see the sign changes in the value of Y1. How many sign changes occur, and at what X values?

| X | Y1 |
|----|-----|
| -3 | -21 |
| -2 | -4 |
| -1 | 1 |
| 0 | 0 |
| 1 | -1 |
| 2 | 4 |
| 3 | 21 |

X = 3

Setting Up the Table

TABLE SETUP Screen

To display the TABLE SETUP screen, press **[2nd] [TBLSET]**.

```
TABLE SETUP
TblStart=0
ΔTbl=1
Indpnt: Auto Ask
Depend: Auto Ask
```

TblStart, ΔTbl

TblStart (table start) defines the initial value for the independent variable. **TblStart** applies only when the independent variable is generated automatically (when **Indpnt: Auto** is selected).

ΔTbl (table step) defines the increment for the independent variable.

Note: In Seq mode, both **TblStart** and **ΔTbl** must be integers.

Indpnt: Auto, Indpnt: Ask, Depend: Auto, Depend: Ask

| Selections | Table Characteristics |
|--------------------------------------|--|
| Indpnt: Auto Depend: Auto | Values are displayed automatically in both the independent-variable column and in all dependent-variable columns. |
| Indpnt: Ask Depend: Auto | The table is empty; when you enter a value for the independent variable, all corresponding dependent-variable values are calculated and displayed automatically. |
| Indpnt: Auto Depend: Ask | Values are displayed automatically for the independent variable; to generate a value for a dependent variable, move the cursor to that cell and press ENTER . |
| Indpnt: Ask Depend: Ask | The table is empty; enter values for the independent variable; to generate a value for a dependent variable, move the cursor to that cell and press ENTER . |

Setting Up the Table from the Home Screen or a Program

To store a value to **TblStart**, **ΔTbl**, or **TblInput** from the home screen or a program, select the variable name from the **VARS TABLE** secondary menu. **TblInput** is a list of independent-variable values in the current table.

When you press **[2nd] [TBLSET]** in the program editor, you can select **IndpntAuto**, **IndpntAsk**, **DependAuto**, and **DependAsk**.

Defining the Dependent Variables

Defining Dependent Variables from the Y= Editor

In the **Y=** editor, enter the functions that define the dependent variables. Only functions that are selected in the **Y=** editor are displayed in the table. The current graphing mode is used. In **Par** mode, you must define both components of each parametric equation (Chapter 4).

Editing Dependent Variables from the Table Editor

To edit a selected **Y=** function from the table editor, follow these steps.

1. Press **2nd** [TABLE] to display the table, then press **▶** or **◀** to move the cursor to a dependent-variable column.
2. Press **▲** until the cursor is on the function name at the top of the column. The function is displayed on the bottom line.

| X | Y1 | |
|---|-----|--|
| 0 | 0 | |
| 1 | -1 | |
| 2 | 4 | |
| 3 | 21 | |
| 4 | 56 | |
| 5 | 115 | |
| 6 | 204 | |

Y1 **■** $X^3 - 2X$

3. Press **ENTER**. The cursor moves to the bottom line. Edit the function.

| X | Y1 | |
|---|-----|--|
| 0 | 0 | |
| 1 | -1 | |
| 2 | 4 | |
| 3 | 21 | |
| 4 | 56 | |
| 5 | 115 | |
| 6 | 204 | |

| X | Y1 | |
|---|-----|--|
| 0 | 0 | |
| 1 | -1 | |
| 2 | 4 | |
| 3 | 21 | |
| 4 | 56 | |
| 5 | 115 | |
| 6 | 204 | |

4. Press **ENTER** or **▼**. The new values are calculated. The table and the **Y=** function are updated automatically.

| X | Y1 | |
|---|-----|--|
| 0 | 0 | |
| 1 | -3 | |
| 2 | 0 | |
| 3 | 15 | |
| 4 | 48 | |
| 5 | 105 | |
| 6 | 192 | |

Note: You also can use this feature to view the function that defines a dependent variable without having to leave the table.

Displaying the Table

The Table

To display the table, press [2nd] [TABLE].

Independent-variable values in the first column →

→ *Dependent-variable values in the second and third columns*

↑
Current cell's full value

Current cell

| X | Y ₁ | Y ₂ |
|----|----------------|----------------|
| 10 | -39.17 | -49.17 |
| 11 | -44.86 | -54.86 |
| 12 | -47.88 | -57.88 |
| 13 | -52.88 | -62.88 |
| 14 | -56.98 | -66.98 |
| 15 | -59.2 | -69.2 |
| 16 | -64.59 | -74.59 |

V₁ = -39.173120459

Note: The table abbreviates the values, if necessary.

Independent and Dependent Variables

The current graphing mode determines which independent and dependent variables are displayed in the table (Chapter 1). In the table above, for example, the independent variable **X** and the dependent variables **Y₁** and **Y₂** are displayed because **Func** graphing mode is set.

| Graphing Mode | Independent Variable | Dependent Variable |
|------------------|----------------------|---|
| Func (function) | X | Y ₁ through Y ₉ , and Y ₀ |
| Par (parametric) | T | X _{1T} /Y _{1T} through X _{6T} /Y _{6T} |
| Pol (polar) | θ | r ₁ through r ₆ |
| Seq (sequence) | n | u(n), v(n), and w(n) |

Clearing the Table from the Home Screen or a Program

From the home screen, select the **ClrTable** instruction from the **CATALOG**. To clear the table, press **[ENTER]**.

From a program, select **9:ClrTable** from the **PRGM I/O** menu or from the **CATALOG**. The table is cleared upon execution. If **IndpntAsk** is selected, all independent and dependent variable values on the table are cleared. If **DependAsk** is selected, all dependent variable values on the table are cleared.

Scrolling Independent-Variable Values

If **Indpnt: Auto** is selected, you can press **▲** and **▼** in the independent-variable column to display more values. As you scroll the column, the corresponding dependent-variable values also are displayed. All dependent-variable values may not be displayed if **Depend: Ask** is selected.

| X | Y ₁ | Y ₂ |
|---|----------------|----------------|
| 0 | 0 | 0 |
| 1 | -1 | -3 |
| 2 | 4 | 0 |
| 3 | 21 | 15 |
| 4 | 56 | 48 |
| 5 | 115 | 105 |
| 6 | 204 | 192 |

X=0

| X | Y ₁ | Y ₂ |
|---|----------------|----------------|
| 0 | 1 | 3 |
| 1 | 0 | -1 |
| 2 | 4 | 0 |
| 3 | 21 | 15 |
| 4 | 56 | 48 |
| 5 | 115 | 105 |

X= -1

Note: You can scroll back from the value entered for **TblStart**. As you scroll, **TblStart** is updated automatically to the value shown on the top line of the table. In the example above, **TblStart=0** and $\Delta \text{Tbl}=1$ generates and displays values of $X=0, \dots, 6$; but you can press \blacktriangleleft to scroll back and display the table for $X=-1, \dots, 5$.

Displaying Other Dependent Variables

If you have defined more than two dependent variables, the first two selected **Y=** functions are displayed initially. Press \triangleright or \triangleleft to display dependent variables defined by other selected **Y=** functions. The independent variable always remains in the left column, except during a trace with **Par** graphing mode and **G-T** split-screen mode set.

| X | Y ₂ | Y ₃ |
|----|----------------|----------------|
| -4 | -4 | -28 |
| -3 | -6 | -18 |
| -2 | -6 | -10 |
| -1 | -4 | -4 |
| 0 | 0 | 0 |
| 1 | 6 | 2 |
| 2 | 14 | 2 |

Y₃= -28

Tip: To simultaneously display two dependent variables on the table that are not defined as consecutive **Y=** functions, go to the **Y=** editor and deselect the **Y=** functions between the two you want to display. For example, to simultaneously display **Y4** and **Y7** on the table, go to the **Y=** editor and deselect **Y5** and **Y6**.

Chapter 8: **Draw Instructions**

Getting Started: Drawing a Tangent Line

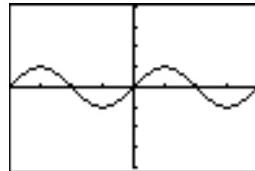
Getting Started is a fast-paced introduction. Read the chapter for details.

Suppose you want to find the equation of the tangent line at $X = \sqrt{2}/2$ for the function $Y = \sin(X)$.

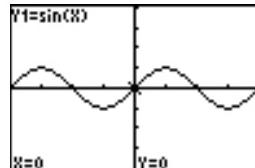
Before you begin, select **Radian** and **Func** mode from the mode screen, if necessary.

1. Press **[Y=]** to display the **Y=** editor. Press **[SIN]** **[X,T,Θ,n]** **[ENTER]** to store **sin(X)** in **Y1**.
2. Press **[ZOOM]** **7** to select **7:ZTrig**, which graphs the equation in the Zoom Trig window.

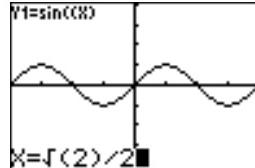
```
Plot1 Plot2 Plot3
\nY1:sin(X)
\nY2=
\nY3=
\nY4=
\nY5=
\nY6=
\nY7=
```



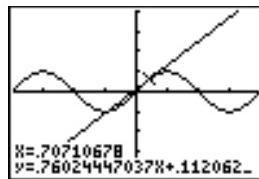
3. Press **[2nd] [DRAW]** **5** to select **5:Tangent(**. The tangent instruction is initiated.



4. Press **[2nd] [$\sqrt{}$] **2** **)** **÷** **2**.**



5. Press **[ENTER]**. The tangent line is drawn; the **X** value and the tangent-line equation are displayed on the graph.



Using the DRAW Menu

DRAW Menu

To display the DRAW menu, press **2nd** [DRAW]. The TI-83 Plus's interpretation of these instructions depends on whether you accessed the menu from the home screen or the program editor or directly from a graph.

DRAW POINTS STO

- | | |
|--------------|---|
| 1:ClrDraw | Clears all drawn elements. |
| 2:Line(| Draws a line segment between 2 points. |
| 3:Horizontal | Draws a horizontal line. |
| 4:Vertical | Draws a vertical line. |
| 5:Tangent(| Draws a line segment tangent to a function. |
| 6:DrawF | Draws a function. |
| 7:Shade(| Shades an area between two functions. |
| 8:DrawInv | Draws the inverse of a function. |
| 9:Circle(| Draws a circle. |
| 0:Text(| Draws text on a graph screen. |
| A:Pen | Activates the free-form drawing tool. |
-

Before Drawing on a Graph

The **DRAW** instructions draw on top of graphs. Therefore, before you use the **DRAW** instructions, consider whether you want to perform one or more of the following actions.

- Change the mode settings on the mode screen.
- Change the format settings on the format screen.
- Enter or edit functions in the **Y=** editor.
- Select or deselect functions in the **Y=** editor.
- Change the window variable values.
- Turn stat plots on or off.
- Clear existing drawings with **ClrDraw**.

Note: If you draw on a graph and then perform any of the actions listed above, the graph is replotted without the drawings when you display the graph again.

Drawing on a Graph

You can use any **DRAW** menu instructions except **DrawInv** to draw on **Func**, **Par**, **Pol**, and **Seq** graphs. **DrawInv** is valid only in **Func** graphing. The coordinates for all **DRAW** instructions are the display's x-coordinate and y-coordinate values.

You can use most **DRAW** menu and **DRAW POINTS** menu instructions to draw directly on a graph, using the cursor to identify the coordinates. You also can execute these instructions from the home screen or from within a program. If a graph is not displayed when you select a **DRAW** menu instruction, the home screen is displayed.

Clearing Drawings

Clearing Drawings When a Graph Is Displayed

All points, lines, and shading drawn on a graph with **DRAW** instructions are temporary.

To clear drawings from the currently displayed graph, select **1:ClrDraw** from the **DRAW** menu. The current graph is replotted and displayed with no drawn elements.

Clearing Drawings from the Home Screen or a Program

To clear drawings on a graph from the home screen or a program, begin on a blank line on the home screen or in the program editor. Select **1:ClrDraw** from the **DRAW** menu. The instruction is copied to the cursor location. Press **ENTER**.

When **ClrDraw** is executed, it clears all drawings from the current graph and displays the message **Done**. When you display the graph again, all drawn points, lines, circles, and shaded areas will be gone.

```
ClrDraw      Done
```

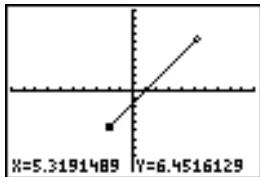
Note: Before you clear drawings, you can store them with **StorePic**.

Drawing Line Segments

Drawing a Line Segment Directly on a Graph

To draw a line segment when a graph is displayed, follow these steps.

1. Select **2:Line(** from the **DRAW** menu.
2. Place the cursor on the point where you want the line segment to begin, and then press **ENTER**.
3. Move the cursor to the point where you want the line segment to end. The line is displayed as you move the cursor. Press **ENTER**.



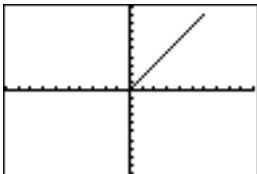
To continue drawing line segments, repeat steps 2 and 3. To cancel **Line(**, press **CLEAR**.

Drawing a Line Segment from the Home Screen or a Program

Line(also draws a line segment between the coordinates (X_1, Y_1) and (X_2, Y_2) . The values may be entered as expressions.

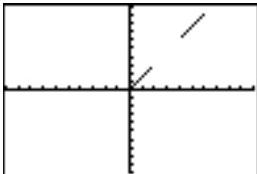
Line(X_1, Y_1, X_2, Y_2)

```
Line(0,0,6,9)■
```



To erase a line segment, enter **Line($X_1, Y_1, X_2, Y_2, 0$)**

```
Line(2,3,4,6,0)■
```

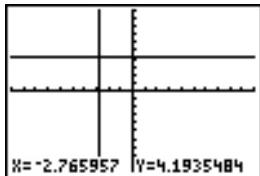


Drawing Horizontal and Vertical Lines

Drawing a Line Directly on a Graph

To draw a horizontal or vertical line when a graph is displayed, follow these steps.

1. Select **3:Horizontal** or **4:Vertical** from the **DRAW** menu. A line is displayed that moves as you move the cursor.
2. Place the cursor on the y-coordinate (for horizontal lines) or x-coordinate (for vertical lines) through which you want the drawn line to pass.
3. Press **ENTER** to draw the line on the graph.



To continue drawing lines, repeat steps 2 and 3.

To cancel **Horizontal** or **Vertical**, press **CLEAR**.

Drawing a Line from the Home Screen or a Program

Horizontal (horizontal line) draws a horizontal line at $Y=y$. y can be an expression but not a list.

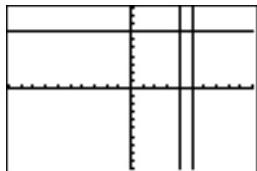
Horizontal y

Vertical (vertical line) draws a vertical line at $X=x$. x can be an expression but not a list.

Vertical x

To instruct the TI-83 Plus to draw more than one horizontal or vertical line, separate each instruction with a colon (:).

```
Horizontal 7:Ver  
tical 4:Vertical  
5■
```

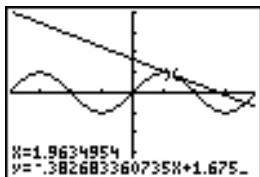


Drawing Tangent Lines

Drawing a Tangent Line Directly on a Graph

To draw a tangent line when a graph is displayed, follow these steps.

1. Select **5:Tangent(** from the **DRAW** menu.
2. Press **▼** and **▲** to move the cursor to the function for which you want to draw the tangent line. The current graph's **Y=** function is displayed in the top-left corner, if **ExprOn** is selected.
3. Press **▶** and **◀** or enter a number to select the point on the function at which you want to draw the tangent line.
4. Press **[ENTER]**. In **Func** mode, the **X** value at which the tangent line was drawn is displayed on the bottom of the screen, along with the equation of the tangent line. In all other modes, the **dy/dx** value is displayed.



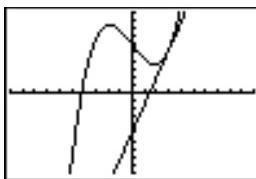
Tip: Change the fixed decimal setting on the mode screen if you want to see fewer digits displayed for X and the equation for Y .

Drawing a Tangent Line from the Home Screen or a Program

Tangent((tangent line) draws a line tangent to *expression* in terms of X , such as Y_1 or X^2 , at point $X=value$. X can be an expression. *expression* is interpreted as being in **Func** mode.

Tangent(*expression,value*)

```
Tangent(Y1,3)■
```



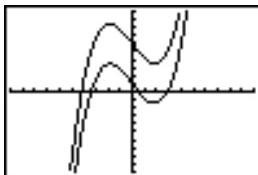
Drawing Functions and Inverses

Drawing a Function

DrawF (draw function) draws *expression* as a function in terms of **X** on the current graph. When you select **6:DrawF** from the **DRAW** menu, the TI-83 Plus returns to the home screen or the program editor. **DrawF** is not interactive.

DrawF *expression*

```
DrawF Y1-5■
```



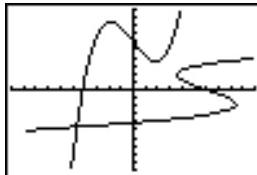
Note: You cannot use a list in *expression* to draw a family of curves.

Drawing an Inverse of a Function

DrawInv (draw inverse) draws the inverse of *expression* by plotting **X** values on the y-axis and **Y** values on the x-axis. When you select **8:DrawInv** from the **DRAW** menu, the TI-83 Plus returns to the home screen or the program editor. **DrawInv** is not interactive. **DrawInv** works in **Func** mode only.

DrawInv *expression*

DrawInv Y₁■



Note: You cannot use a list in *expression* to draw a family of curves.

Shading Areas on a Graph

Shading a Graph

To shade an area on a graph, select **7:Shade(** from the **DRAW** menu. The instruction is pasted to the home screen or to the program editor.

Shade(draws *lowerfunc* and *upperfunc* in terms of **X** on the current graph and shades the area that is specifically above *lowerfunc* and below *upperfunc*. Only the areas where *lowerfunc* < *upperfunc* are shaded.

Xleft and *Xright*, if included, specify left and right boundaries for the shading. *Xleft* and *Xright* must be numbers between **Xmin** and **Xmax**, which are the defaults.

pattern specifies one of four shading patterns.

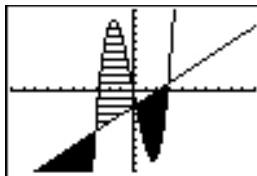
| | |
|------------------|--------------------|
| <i>pattern=1</i> | vertical (default) |
| <i>pattern=2</i> | horizontal |
| <i>pattern=3</i> | negative—slope 45° |
| <i>pattern=4</i> | positive—slope 45° |

patres specifies one of eight shading resolutions.

- patres=1* shades every pixel (default)
- patres=2* shades every second pixel
- patres=3* shades every third pixel
- patres=4* shades every fourth pixel
- patres=5* shades every fifth pixel
- patres=6* shades every sixth pixel
- patres=7* shades every seventh pixel
- patres=8* shades every eighth pixel

Shade(*lowerfunc,upperfunc[,Xleft,Xright,pattern,patres]*)

```
Shade(X³-8X,X-2)
:Shade(X-2,X³-8X
,-3,2,2,3)
```

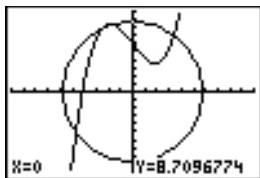


Drawing Circles

Drawing a Circle Directly on a Graph

To draw a circle directly on a displayed graph using the cursor, follow these steps.

1. Select **9:Circle(** from the **DRAW** menu.
2. Place the cursor at the center of the circle you want to draw. Press **[ENTER]**.
3. Move the cursor to a point on the circumference. Press **[ENTER]** to draw the circle on the graph.



Note: This circle is displayed as circular, regardless of the window variable values, because you drew it directly on the display. When you use the **Circle(** instruction from the home screen or a program, the current window variables may distort the shape.

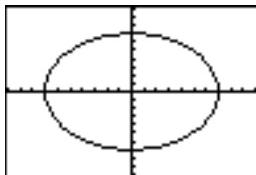
To continue drawing circles, repeat steps 2 and 3. To cancel **Circle(**, press **CLEAR**.

Drawing a Circle from the Home Screen or a Program

Circle(draws a circle with center (X, Y) and *radius*. These values can be expressions.

Circle($X, Y, radius$)

```
Circle(0,0,7)■
```



Tip: When you use **Circle(** on the home screen or from a program, the current window values may distort the drawn circle. Use **ZSquare** (Chapter 3) before drawing the circle to adjust the window variables and make the circle circular.

Placing Text on a Graph

Placing Text Directly on a Graph

To place text on a graph when the graph is displayed, follow these steps.

1. Select **0:Text(** from the **DRAW** menu.
2. Place the cursor where you want the text to begin.
3. Enter the characters. Press **[ALPHA]** or **[2nd] [A-LOCK]** to enter letters and θ . You may enter TI-83 Plus functions, variables, and instructions. The font is proportional, so the exact number of characters you can place on the graph varies. As you type, the characters are placed on top of the graph.

To cancel **Text(**, press **[CLEAR]**.

Placing Text on a Graph from the Home Screen or a Program

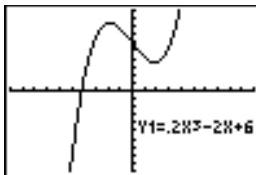
Text(places on the current graph the characters comprising *value*, which can include TI-83 Plus functions and instructions. The top-left corner of the first character is at pixel $(row, column)$, where *row* is an integer between 0 and 57 and *column* is an integer between 0 and 94. Both *row* and *column* can be expressions.

| | |
|--------|---------|
| (0,0) | (0,94) |
| (57,0) | (57,94) |

Text(*row*,*column*,*value*,*value*...)

value can be text enclosed in quotation marks ("), or it can be an expression. The TI-83 Plus will evaluate an expression and display the result with up to 10 characters.

```
Text(42,50,"Y1=.  
2X^3-2X+6")■
```



Split Screen

On a **Horiz** split screen, the maximum value for *row* is 25. On a **G-T** split screen, the maximum value for *row* is 45, and the maximum value for *column* is 46.

Using Pen to Draw on a Graph

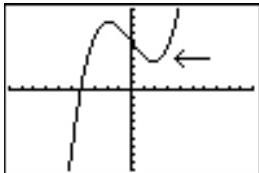
Using Pen to Draw on a Graph

Pen draws directly on a graph only. You cannot execute **Pen** from the home screen or a program.

To draw on a displayed graph, follow these steps.

1. Select **A:Pen** from the **DRAW** menu.
2. Place the cursor on the point where you want to begin drawing. Press **[ENTER]** to turn on the pen.
3. Move the cursor. As you move the cursor, you draw on the graph, shading one pixel at a time.
4. Press **[ENTER]** to turn off the pen.

For example, **Pen** was used to create the arrow pointing to the local minimum of the selected function.



Note: To continue drawing on the graph, move the cursor to a new position where you want to begin drawing again, and then repeat steps 2, 3, and 4. To cancel **Pen**, press **[CLEAR]**.

Drawing Points on a Graph

DRAW POINTS Menu

To display the DRAW POINTS menu, press **[2nd]** [DRAW] **[▶]**. The TI-83 Plus's interpretation of these instructions depends on whether you accessed this menu from the home screen or the program editor or directly from a graph.

DRAW POINTS STO

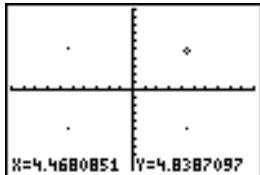
| | |
|---------------|--|
| 1:Pt-On(| Turns on a point. |
| 2:Pt-Off(| Turns off a point. |
| 3:Pt-Change(| Toggles a point on or off. |
| 4:Px1-On(| Turns on a pixel. |
| 5:Px1-Off(| Turns off a pixel. |
| 6:Px1-Change(| Toggles a pixel on or off. |
| 7:px1-Test(| Returns 1 if pixel on, 0 if pixel off. |

Drawing Points Directly on a Graph with Pt-On(

To draw a point on a graph, follow these steps.

1. Select 1:Pt-On(from the DRAW POINTS menu.
2. Move the cursor to the position where you want to draw the point.

3. Press **[ENTER]** to draw the point.



To continue drawing points, repeat steps 2 and 3. To cancel Pt-On, press **[CLEAR]**.

Erasing Points with Pt-Off(

To erase (turn off) a drawn point on a graph, follow these steps.

1. Select **2:Pt-Off(** (point off) from the **DRAW POINTS** menu.
2. Move the cursor to the point you want to erase.
3. Press **[ENTER]** to erase the point.

To continue erasing points, repeat steps 2 and 3. To cancel Pt-Off(, press **[CLEAR]**.

Changing Points with Pt-Change(

To change (toggle on or off) a point on a graph, follow these steps.

1. Select 3:Pt-Change((point change) from the DRAW POINTS menu.
2. Move the cursor to the point you want to change.
3. Press **ENTER** to change the point's on/off status.

To continue changing points, repeat steps 2 and 3. To cancel Pt-Change(, press **CLEAR**.

Drawing Points from the Home Screen or a Program

Pt-On((point on) turns on the point at $(X=x, Y=y)$. **Pt-Off(** turns the point off.

Pt-Change(toggles the point on or off. *mark* is optional; it determines the point's appearance; specify 1, 2, or 3, where:

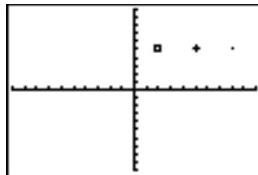
1 = • (dot; default) **2 = □** (box) **3 = +** (cross)

Pt-On($x,y[,mark]$)

Pt-Off($x,y[,mark]$)

Pt-Change(x,y)

```
Pt-On(2,5,2):Pt-  
On(5,5,3):Pt-On(  
8,5,1)
```

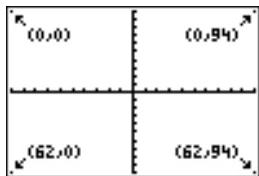


Note: If you specified *mark* to turn on a point with **Pt-On(**, you must specify *mark* when you turn off the point with **Pt-Off(**. **Pt-Change(** does not have the *mark* option.

Drawing Pixels

TI-83 Plus Pixels

A pixel is a square dot on the TI-83 Plus display. The **Pxl-** (pixel) instructions let you turn on, turn off, or reverse a pixel (dot) on the graph using the cursor. When you select a pixel instruction from the **DRAW POINTS** menu, the TI-83 Plus returns to the home screen or the program editor. The pixel instructions are not interactive.



Turning On and Off Pixels with **Pxl-On(** and **Pxl-Off(**

Pxl-On((pixel on) turns on the pixel at $(row, column)$, where row is an integer between 0 and 62 and $column$ is an integer between 0 and 94.

Pxl-Off(turns the pixel off. **Pxl-Change(** toggles the pixel on and off.

Pxl-On($row, column$)

Pxl-Off($row, column$)

Pxl-Change($row, column$)

Using pxi-Test(

pxl-Test((pixel test) returns 1 if the pixel at $(row, column)$ is turned on or 0 if the pixel is turned off on the current graph. *row* must be an integer between 0 and 62. *column* must be an integer between 0 and 94.

pxl-Test(*row*,*column*)

Split Screen

On a **Horiz** split screen, the maximum value for *row* is 30 for **Pxl-On(**, **Pxl-Off(**, **Pxl-Change(**, and **pxl-Test(**.

On a **G-T** split screen, the maximum value for *row* is 50 and the maximum value for *column* is 46 for **Pxl-On(**, **Pxl-Off(**, **Pxl-Change(**, and **pxl-Test(**.

Storing Graph Pictures (Pic)

DRAW STO Menu

To display the **DRAW STO** menu, press **2nd [DRAW] ▶**. When you select an instruction from the **DRAW STO** menu, the TI-83 Plus returns to the home screen or the program editor. The picture and graph database instructions are not interactive.

DRAW POINTS **STO**

- | | |
|---------------------|------------------------------------|
| 1: StorePic | Stores the current picture. |
| 2: RecallPic | Recalls a saved picture. |
| 3: StoreGDB | Stores the current graph database. |
| 4: RecallGDB | Recalls a saved graph database. |
-

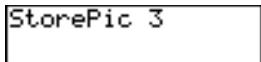
Storing a Graph Picture

You can store up to 10 graph pictures, each of which is an image of the current graph display, in picture variables **Pic1** through **Pic9**, or **Pic0**. Later, you can superimpose the stored picture onto a displayed graph from the home screen or a program.

A picture includes drawn elements, plotted functions, axes, and tick marks. The picture does not include axes labels, lower and upper bound indicators, prompts, or cursor coordinates. Any parts of the display hidden by these items are stored with the picture.

To store a graph picture, follow these steps.

1. Select **1:StorePic** from the **DRAW STO** menu. **StorePic** is pasted to the current cursor location.
2. Enter the number (from **1** to **9**, or **0**) of the picture variable to which you want to store the picture. For example, if you enter **3**, the TI-83 Plus will store the picture to **Pic3**.



StorePic 3

Note: You also can select a variable from the **PICTURE** secondary menu (**[VARS] 4**). The variable is pasted next to **StorePic**.

3. Press **ENTER** to display the current graph and store the picture.

Recalling Graph Pictures (Pic)

Recalling a Graph Picture

To recall a graph picture, follow these steps.

1. Select **2:RecallPic** from the **DRAW STO** menu. **RecallPic** is pasted to the current cursor location.
2. Enter the number (from **1** to **9**, or **0**) of the picture variable from which you want to recall a picture. For example, if you enter **3**, the TI-83 Plus will recall the picture stored to **Pic3**.

RecallPic 3

Note: You also can select a variable from the **PICTURE** secondary menu (**[VARS] 4**). The variable is pasted next to **RecallPic**.

3. Press **[ENTER]** to display the current graph with the picture superimposed on it.

Note: Pictures are drawings. You cannot trace a curve that is part of a picture.

Deleting a Graph Picture

To delete graph pictures from memory, use the **MEMORY MANAGEMENT /DELETE** secondary menu (Chapter 18).

Storing Graph Databases (GDB)

What Is a Graph Database?

A graph database (**GDB**) contains the set of elements that defines a particular graph. You can recreate the graph from these elements. You can store up to 10 **GDBs** in variables **GDB1** through **GDB9**, or **GDB0** and recall them to recreate graphs.

A **GDB** stores five elements of a graph.

- Graphing mode
- Window variables
- Format settings
- All functions in the **Y=** editor and the selection status of each
- Graph style for each **Y=** function

GDBs do not contain drawn items or stat plot definitions.

Storing a Graph Database

To store a graph database, follow these steps.

1. Select **3:StoreGDB** from the **DRAW STO** menu. **StoreGDB** is pasted to the current cursor location.

2. Enter the number (from **1** to **9**, or **0**) of the **GDB** variable to which you want to store the graph database. For example, if you enter **7**, the TI-83 Plus will store the **GDB** to **GDB7**.

```
StoreGDB 7
```

Note: You also can select a variable from the **GDB** secondary menu (**[VARS] 3**). The variable is pasted next to **StoreGDB**.

3. Press **[ENTER]** to store the current database to the specified **GDB** variable.

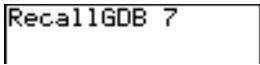
Recalling Graph Databases (GDB)

Recalling a Graph Database

CAUTION: When you recall a **GDB**, it replaces all existing **Y=** functions. Consider storing the current **Y=** functions to another database before recalling a stored **GDB**.

To recall a graph database, follow these steps.

1. Select **4:RecallGDB** from the **DRAW STO** menu. **RecallGDB** is pasted to the current cursor location.
2. Enter the number (from **1** to **9**, or **0**) of the **GDB** variable from which you want to recall a **GDB**. For example, if you enter **7**, the TI-83 Plus will recall the **GDB** stored to **GDB7**.



RecallGDB ?

Note: You also can select a variable from the **GDB** secondary menu (**[VARS] 3**). The variable is pasted next to **RecallGDB**.

3. Press **ENTER** to replace the current **GDB** with the recalled **GDB**. The new graph is not plotted. The TI-83 Plus changes the graphing mode automatically, if necessary.

Deleting a Graph Database

To delete a **GDB** from memory, use the **MEMORY MANAGEMENT/DELETE** secondary menu (Chapter 18).

Chapter 9: **Split Screen**

Getting Started: Exploring the Unit Circle

Getting Started is a fast-paced introduction. Read the chapter for details.

Use G-T (graph-table) split-screen mode to explore the unit circle and its relationship to the numeric values for the commonly used trigonometric angles of 0° , 30° , 45° , 60° , 90° , and so on.

1. Press **[MODE]** to display the mode screen. Press **[▼] [▼] [▶] [ENTER]** to select Degree mode. Press **[▼] [▶] [ENTER]** to select Par (parametric) graphing mode.

Press **[▼] [▼] [▼] [▼] [▶] [▶] [ENTER]** to select G-T (graph-table) split-screen mode.

2. Press **[2nd] [FORMAT]** to display the format screen. Press **[▼] [▼] [▼] [▼] [▼] [▶] [ENTER]** to select ExprOff.



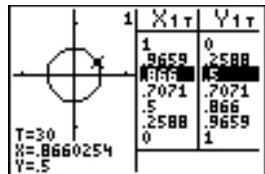
3. Press **[Y=]** to display the **Y=** editor for **Par** graphing mode. Press **COS [X,T,θ,n] () [ENTER]** to store **cos(T)** to **X_{1T}**. Press **SIN [X,T,θ,n] () [ENTER]** to store **sin(T)** to **Y_{1T}**.

| Plot1 | Plot2 | Plot3 |
|------------------------------------|-------|-------|
| $\checkmark X_{1T} \equiv \cos(T)$ | | |
| $\checkmark Y_{1T} \equiv \sin(T)$ | | |
| $\checkmark X_{2T} =$ | | |
| $\checkmark Y_{2T} =$ | | |
| $\checkmark X_{3T} =$ | | |
| $\checkmark Y_{3T} =$ | | |
| $\checkmark X_{4T} =$ | | |

4. Press **[WINDOW]** to display the window editor. Enter these values for the window variables.

| | | |
|-----------------|------------------|------------------|
| Tmin=0 | Xmin=-2.3 | Ymin=-2.5 |
| Tmax=360 | Xmax=2.3 | Ymax=2.5 |
| Tstep=15 | Xscl=1 | Yscl=1 |

5. Press **[TRACE]**. On the left, the unit circle is graphed parametrically in **Degree** mode and the trace cursor is activated. When **T=0** (from the graph trace coordinates), you can see from the table on the right that the value of **X_{1T} (cos(T))** is **1** and **Y_{1T} (sin(T))** is **0**. Press **[** **]** to move the cursor to the next 15° angle increment. As you trace around the circle in steps of 15°, an approximation of the standard value for each angle is highlighted in the table.



Using Split Screen

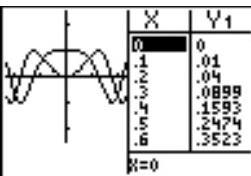
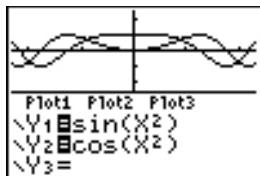
Setting a Split-Screen Mode

To set a split-screen mode, press **MODE**, and then move the cursor to the bottom line of the mode screen.

- Select **Horiz** (horizontal) to display the graph screen and another screen split horizontally.
- Select **G-T** (graph-table) to display the graph screen and table screen split vertically.

Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real $a+bi$ re θ i
Full Horiz G-T

Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real $a+bi$ re θ i
Full Horiz G-T



The split screen is activated when you press any key that applies to either half of the split screen.

Some screens are never displayed as split screens. For example, if you press **[MODE]** in **Horiz** or **G-T** mode, the mode screen is displayed as a full screen. If you then press a key that displays either half of a split screen, such as **[TRACE]**, the split screen returns.

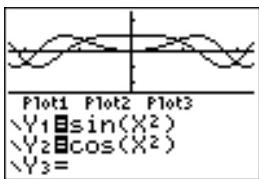
When you press a key or key combination in either **Horiz** or **G-T** mode, the cursor is placed in the half of the display for which that key applies. For example, if you press **[TRACE]**, the cursor is placed in the half in which the graph is displayed. If you press **[2nd]** **[TABLE]**, the cursor is placed in the half in which the table is displayed.

The TI-83 Plus will remain in split-screen mode until you change back to Full screen mode.

Horiz (Horizontal) Split Screen

Horiz Mode

In **Horiz** (horizontal) split-screen mode, a horizontal line splits the screen into top and bottom halves.



The top half displays the graph.

The bottom half displays any of these editors.

- Home screen (four lines)
- **Y=** editor (four lines)
- Stat list editor (two rows)
- Window editor (three settings)
- Table editor (two rows)

Moving from Half to Half in Horiz Mode

To use the top half of the split screen:

- Press **[GRAPH]** or **[TRACE]**.
- Select a **ZOOM** or **CALC** operation.

To use the bottom half of the split screen:

- Press any key or key combination that displays the home screen.
- Press **[Y=]** (**Y=** editor).
- Press **[STAT]** **[ENTER]** (stat list editor).
- Press **[WINDOW]** (window editor).
- Press **[2nd]** **[TABLE]** (table editor).

Full Screens in Horiz Mode

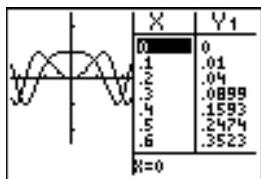
All other screens are displayed as full screens in **Horiz** split-screen mode.

To return to the **Horiz** split screen from a full screen when in **Horiz** mode, press any key or key combination that displays the graph, home screen, **Y=** editor, stat list editor, window editor, or table editor.

G-T (Graph-Table) Split Screen

G-T Mode

In G-T (graph-table) split-screen mode, a vertical line splits the screen into left and right halves.



The left half displays the graph.

The right half displays the table.

Moving from Half to Half in G-T Mode

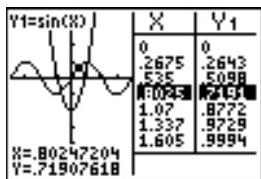
To use the left half of the split screen:

- Press **[GRAPH]** or **[TRACE]**.
- Select a **ZOOM** or **CALC** operation.

To use the right half of the split screen, press **[2nd] [TABLE]**.

Using **TRACE** in G-T Mode

As you move the trace cursor along a graph in the split screen's left half in **G-T** mode, the table on the right half automatically scrolls to match the current cursor values.



Note: When you trace in **Par** graphing mode, both components of an equation (**XnT** and **YnT**) are displayed in the two columns of the table. As you trace, the current value of the independent variable **T** is displayed on the graph.

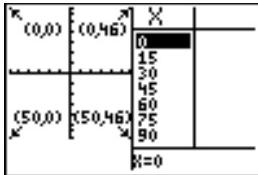
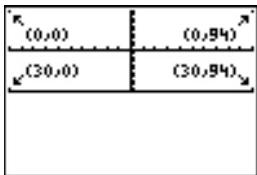
Full Screens in G-T Mode

All screens other than the graph and the table are displayed as full screens in **G-T** split-screen mode.

To return to the **G-T** split screen from a full screen when in **G-T** mode, press any key or key combination that displays the graph or the table.

TI-83 Plus Pixels in Horiz and G-T Modes

TI-83 Plus Pixels in Horiz and G-T Modes



Note: Each set of numbers in parentheses above represents the row and column of a corner pixel, which is turned on.

DRAW POINTS Menu Pixel Instructions

For `Pxl-On(`, `Pxl-Off(`, `Pxl-Change(`, and `pxl-Test(`:

- In **Horiz** mode, *row* must be ≤ 30 ; *column* must be ≤ 94 .
- In **G-T** mode, *row* must be ≤ 50 ; *column* must be ≤ 46 .

`Pxl-On(row,column)`

DRAW Menu Text(Instruction

For the `Text(` instruction:

- In **Horiz** mode, *row* must be ≤ 25 ; *column* must be ≤ 94 .

- In **G-T** mode, *row* must be ≤ 45 ; *column* must be ≤ 46 .

Text(*row*,*column*, "text")

PRGM I/O Menu Output(Instruction

For the **Output**(instruction:

- In **Horiz** mode, *row* must be ≤ 4 ; *column* must be ≤ 16 .
- In **G-T** mode, *row* must be ≤ 8 ; *column* must be ≤ 16 .

Output(*row*,*column*, "text")

Setting a Split-Screen Mode from the Home Screen or a Program

To set **Horiz** or **G-T** from a program, follow these steps.

1. Press **MODE** while the cursor is on a blank line in the program editor.
2. Select **Horiz** or **G-T**.

The instruction is pasted to the cursor location. The mode is set when the instruction is encountered during program execution. It remains in effect after execution.

Note: You also can paste **Horiz** or **G-T** to the home screen or program editor from the **CATALOG** (Chapter 15).

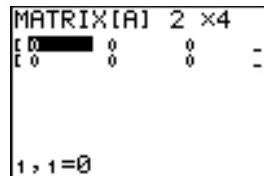
Chapter 10: **Matrices**

Getting Started: Systems of Linear Equations

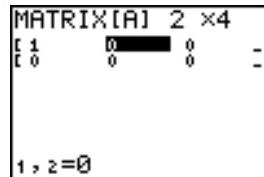
Getting Started is a fast-paced introduction. Read the chapter for details.

Find the solution of $X + 2Y + 3Z = 3$ and $2X + 3Y + 4Z = 3$. On the TI-83 Plus, you can solve a system of linear equations by entering the coefficients as elements in a matrix, and then using rref(to obtain the reduced row-echelon form.

1. Press **2nd** **[MATRIX]**. Press **►** **►** to display the **MATRX EDIT** menu. Press **1** to select **1: [A]**,
2. Press **2** **[ENTER]** **4** **[ENTER]** to define a 2×4 matrix. The rectangular cursor indicates the current element. Ellipses (...) indicate additional columns beyond the screen.
3. Press **1** **[ENTER]** to enter the first element. The rectangular cursor moves to the second column of the first row.



MATRIX[A] 2 ×4
[] [] [] []
1, 1=0



MATRIX[A] 2 ×4
[1] [] [] []
1, 2=0

- Press 2 [ENTER] 3 [ENTER] 3 [ENTER] to complete the first row for $X + 2Y + 3Z = 3$.
- Press 2 [ENTER] 3 [ENTER] 4 [ENTER] 3 [ENTER] to enter the second row for $2X + 3Y + 4Z = 3$.
- Press [2nd] [QUIT] to return to the home screen. If necessary, press [CLEAR] to clear the home screen. Press [2nd] [MATRIX] ▶ to display the **MATRX MATH** menu. Press ▲ to wrap to the end of the menu. Select **B:rref(** to copy **rref(** to the home screen.
- Press [2nd] [MATRIX] 1 to select **1: [A]** from the **MATRX NAMES** menu. Press [)] [ENTER]. The reduced row-echelon form of the matrix is displayed and stored in **Ans**.

$$1X - 1Z = -3 \quad \text{therefore} \quad X = -3 + Z$$

$$1Y + 2Z = 3 \quad \text{therefore} \quad Y = 3 - 2Z$$

MATRIX[A] 2 ×4
 $\begin{bmatrix} 2 & 3 & 2 \\ -3 & 4 & 3 \end{bmatrix}$
 $z, 4=3$

rref(

rref([A])
 $\begin{bmatrix} 1 & 0 & -1 & -3 \\ 0 & 1 & 2 & 3 \end{bmatrix}$

Defining a Matrix

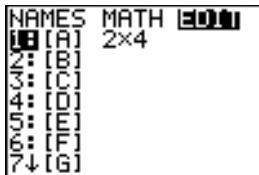
What Is a Matrix?

A matrix is a two-dimensional array. You can display, define, or edit a matrix in the matrix editor. The TI-83 Plus has 10 matrix variables, [A] through [J]. You can define a matrix directly in an expression. A matrix, depending on available memory, may have up to 99 rows or columns. You can store only real numbers in TI-83 Plus matrices.

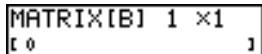
Selecting a Matrix

Before you can define or display a matrix in the editor, you first must select the matrix name. To do so, follow these steps.

1. Press **2nd** **MATRIX** **1** to display the **MATRX EDIT** menu. The dimensions of any previously defined matrices are displayed.



2. Select the matrix you want to define. The **MATRX EDIT** screen is displayed.



MATRIX[B] 1 ×1
[0]

Accepting or Changing Matrix Dimensions

The dimensions of the matrix (*row* \times *column*) are displayed on the top line. The dimensions of a new matrix are **1 ×1**. You must accept or change the dimensions each time you edit a matrix. When you select a matrix to define, the cursor highlights the row dimension.

- To accept the row dimension, press **[ENTER]**.
- To change the row dimension, enter the number of rows (up to **99**), and then press **[ENTER]**.

The cursor moves to the column dimension, which you must accept or change the same way you accepted or changed the row dimension.

When you press **[ENTER]**, the rectangular cursor moves to the first matrix element.

Viewing and Editing Matrix Elements

Displaying Matrix Elements

After you have set the dimensions of the matrix, you can view the matrix and enter values for the matrix elements. In a new matrix, all values are zero.

Select the matrix from the **MATRIX EDIT** menu and enter or accept the dimensions. The center portion of the matrix editor displays up to seven rows and three columns of a matrix, showing the values of the elements in abbreviated form if necessary. The full value of the current element, which is indicated by the rectangular cursor, is displayed on the bottom line.

| MATRIX[A] 8 × 4 | | | |
|-----------------|-------------|----|---|
| 1 | 3.141592653 | 13 | - |
| -1 | 3.1416 | 0 | - |
| 0 | 0 | 0 | - |
| 0 | BB | 0 | - |
| 1.B | 0 | 0 | - |
| 0 | .85714 | 0 | - |
| 0 | 0 | 2 | 4 |

This is an 8×4 matrix. Ellipses in the left or right column indicate additional columns. \uparrow or \downarrow in the right column indicate additional rows.

Deleting a Matrix

To delete matrices from memory, use the **MEMORY MANAGEMENT/DELETE** secondary menu (Chapter 18).

Viewing a Matrix

The matrix editor has two contexts, viewing and editing. In viewing context, you can use the cursor keys to move quickly from one matrix element to the next. The full value of the highlighted element is displayed on the bottom line.

Select the matrix from the **MATRIX EDIT** menu, and then enter or accept the dimensions.

```
MATRIX[A] 8 x4
[ 3.1415 -3.142 13  -
[ -1 3.1416 0 -
[ 0 0 0 -
[ 0 0 BB -
[ 1.8 0 0 -
[ 0 .85714 0 -
[ 0 0 2 -
1, 1=3.141592653
```

Viewing-Context Keys

| Key | Function |
|---------------------|--|
| [◀] or [▶] | Moves the rectangular cursor within the current row |
| [▼] or [▲] | Moves the rectangular cursor within the current column; on the top row, [▲] moves the cursor to the column dimension; on the column dimension, [▲] moves the cursor to the row dimension |
| [ENTER] | Switches to editing context; activates the edit cursor on the bottom line |
| [CLEAR] | Switches to editing context; clears the value on the bottom line |
| Any entry character | Switches to editing context; clears the value on the bottom line; copies the character to the bottom line |
| [2nd] [INS] | Nothing |
| [DEL] | Nothing |

Editing a Matrix Element

In editing context, an edit cursor is active on the bottom line. To edit a matrix element value, follow these steps.

1. Select the matrix from the **MATRIX EDIT** menu, and then enter or accept the dimensions.

2. Press \blacktriangleleft , \blacktriangleright , \blacktriangleup , and \blacktriangledown to move the cursor to the matrix element you want to change.
3. Switch to editing context by pressing **[ENTER]**, **[CLEAR]**, or an entry key.
4. Change the value of the matrix element using the editing-context keys described below. You may enter an expression, which is evaluated when you leave editing context.

Note: You can press **[CLEAR]** **[ENTER]** to restore the value at the rectangular cursor if you make a mistake.

5. Press **[ENTER]**, \blacktriangleup , or \blacktriangledown to move to another element.

| MATRIX[A1] 8 × 4 | | | |
|------------------|---------|----|---|
| 3.1416 | -3.1416 | 13 | - |
| 2222 | 3.1416 | 0 | - |
| 0 | 0 | 0 | - |
| 0 | 0 | BB | - |
| 1.8 | 0 | 0 | - |
| 0 | .85714 | 0 | - |
| 0 | 0 | 2 | ↓ |
| 3, 1=2X^2+3 | | | |

| MATRIX[A1] 8 × 4 | | | |
|------------------|---------|----|---|
| 3.1416 | -3.1416 | 13 | - |
| 2222 | 3.1416 | 0 | - |
| 112.33 | 0 | 0 | - |
| 0 | 0 | BB | - |
| 1.8 | 0 | 0 | - |
| 0 | .85714 | 0 | - |
| 0 | 0 | 2 | ↓ |
| 3, 2=0 | | | |

Editing-Context Keys

| Key | Function |
|---------------------|---|
| [◀] or [▶] | Moves the edit cursor within the value |
| [▼] or [▲] | Stores the value displayed on the bottom line to the matrix element; switches to viewing context and moves the rectangular cursor within the column |
| [ENTER] | Stores the value displayed on the bottom line to the matrix element; switches to viewing context and moves the rectangular cursor to the next row element |
| [CLEAR] | Clears the value on the bottom line |
| Any entry character | Copies the character to the location of the edit cursor on the bottom line |
| [2nd] [INS] | Activates the insert cursor |
| [DEL] | Deletes the character under the edit cursor on the bottom line |

Using Matrices with Expressions

Using a Matrix in an Expression

To use a matrix in an expression, you can do any of the following.

- Copy the name from the **MATRIX NAMES** menu.
- Recall the contents of the matrix into the expression with **2nd [RCL]** (Chapter 1).
- Enter the matrix directly (see below).

Entering a Matrix in an Expression

You can enter, edit, and store a matrix in the matrix editor. You also can enter a matrix directly in an expression.

To enter a matrix in an expression, follow these steps.

1. Press **2nd [[]** to indicate the beginning of the matrix.
2. Press **2nd [[]** to indicate the beginning of a row.
3. Enter a value, which can be an expression, for each element in the row. Separate the values with commas.
4. Press **2nd []** to indicate the end of a row.

5. Repeat steps 2 through 4 to enter all of the rows.
6. Press **[2nd] []** to indicate the end of the matrix.

Note: The closing **]** are not necessary at the end of an expression or preceding **→**.

The resulting matrix is displayed in the form:

[[element_{1,1}, ..., element_{1,n}], ..., [element_{m,1}, ..., element_{m,n}]]

Any expressions are evaluated when the entry is executed.

```
2*[[1,2,3][4,5,6]
[]      [[2 4 6]
[8 10 12]]]
```

Note: The commas that you must enter to separate elements are not displayed on output.

Displaying and Copying Matrices

Displaying a Matrix

To display the contents of a matrix on the home screen, select the matrix from the **MATRX NAMES** menu, and then press **[ENTER]**.

```
[A] [[7 8 9]
      [3 2 1]]
```

Ellipses in the left or right column indicate additional columns. ↑ or ↓ in the right column indicate additional rows. Press **[▼]**, **[◀]**, **[▼]**, and **[▶]** to scroll the matrix.

```
.46.0000 161.0↑
..116.0000 -188.0...
..49.0000 -62.0...
..235.0000 -96.0...
..2.0000 65.0...
..47.0000 136.0...
..3.0000 -69.0↓
```

Copying One Matrix to Another

To copy a matrix, follow these steps.

1. Press **[2nd] [MATRIX]** to display the **MATRX NAMES** menu.
2. Select the name of the matrix you want to copy.

3. Press **STO►**.
4. Press **2nd [MATRIX]** again and select the name of the new matrix to which you want to copy the existing matrix.
5. Press **[ENTER]** to copy the matrix to the new matrix name.

```
[A]→[B]
[[7 8 9]
 [3 2 1]]
```

Accessing a Matrix Element

On the home screen or from within a program, you can store a value to, or recall a value from, a matrix element. The element must be within the currently defined matrix dimensions. Select *matrix* from the **MATRX NAMES** menu.

[matrix](row,column)

```
0→[B](2,3):[B]
[[7 8 9]
 [3 2 0]]
[B](2,3)
0
```

Using Math Functions with Matrices

Using Math Functions with Matrices

You can use many of the math functions on the TI-83 Plus keyboard, the **MATH** menu, the **MATH NUM** menu, and the **MATH TEST** menu with matrices. However, the dimensions must be appropriate. Each of the functions below creates a new matrix; the original matrix remains the same.

+ (Add), – (Subtract), * (Multiply)

To add ($\boxed{+}$) or subtract ($\boxed{-}$) matrices, the dimensions must be the same. The answer is a matrix in which the elements are the sum or difference of the individual corresponding elements.

matrixA $\boxed{+}$ *matrixB*

matrixA $\boxed{-}$ *matrixB*

To multiply ($\boxed{\times}$) two matrices together, the column dimension of *matrixA* must match the row dimension of *matrixB*.

*matrixA***matrixB*

$$\begin{bmatrix} [A] \\ [B] \end{bmatrix} \quad \begin{bmatrix} [[2\ 2]\\ [3\ 4]] \\ [[0\ 5]\\ [4\ 3]] \end{bmatrix}$$

$$\begin{bmatrix} [A]+[B] \\ [A]*[B] \end{bmatrix} \quad \begin{bmatrix} [[2\ 7]\\ [7\ 7]] \\ [[8\ 16]\\ [16\ 27]] \end{bmatrix}$$

Multiplying a *matrix* by a *value* or a *value* by a *matrix* returns a matrix in which each element of *matrix* is multiplied by *value*.

*matrix***value*

*value***matrix*

$$\begin{bmatrix} [A]*3 \\ [[6\ 6]\\ [9\ 12]] \end{bmatrix}$$

- (Negation)

Negating a matrix ($\boxed{-}$) returns a matrix in which the sign of every element is changed (reversed).

$-\text{matrix}$

$$\begin{bmatrix} [A] \\ -[A] \end{bmatrix} \quad \begin{bmatrix} [[2\ -2]\\ [-3\ 4]] \\ [[-2\ 2]\\ [-3\ -4]] \end{bmatrix}$$

abs(

abs((absolute value, **MATH NUM** menu) returns a matrix containing the absolute value of each element of *matrix*.

abs(*matrix*)

```
[C]   [[ -23  -69]
      [-25  -14]]
abs([C])
[[23  69]
 [25  14]]
```

round(

round((**MATH NUM** menu) returns a matrix. It rounds every element in *matrix* to *#decimals* (≤ 9). If *#decimals* is omitted, the elements are rounded to 10 digits.

round(*matrix*[,*#decimals*])

```
MATRIX[A] 2 x2
[[1.259  2.333]
 [3.662  4.121]]
```



```
round([A],2)
[[1.26  2.33]
 [3.66  4.12]]
```

$^{-1}$ (Inverse)

Use the $^{-1}$ function ($\boxed{x^{-1}}$) to invert a matrix ($^{\wedge}-1$ is not valid). *matrix* must be square. The determinant cannot equal zero.

matrix⁻¹

MATRIX[A] 2 ×2
[$\begin{bmatrix} \frac{1}{3} & \frac{2}{3} \\ 1 & 4 \end{bmatrix}$]

[A]⁻¹ [$\begin{bmatrix} -2 & 1 \\ 1.5 & -0.5 \end{bmatrix}$]

Powers

To raise a matrix to a power, *matrix* must be square. You can use ² (x^2), ³ (MATH menu), or ^{power} (\wedge) for integer *power* between **0** and **255**.

*matrix*²

*matrix*³

matrix^{power}

MATRIX[A] 2 ×2
[$\begin{bmatrix} \frac{1}{3} & \frac{2}{3} \\ 1 & 4 \end{bmatrix}$]

[A]³ [$\begin{bmatrix} 37 & 54 \\ 81 & 118 \end{bmatrix}$]
[A]⁵ [$\begin{bmatrix} 1069 & 1558 \\ 2337 & 3406 \end{bmatrix}$]

Relational Operations

To compare two matrices using the relational operations = and ≠ (TEST menu), they must have the same dimensions. = and ≠ compare *matrixA* and *matrixB* on an element-by-element basis. The other relational operations are not valid with matrices.

matrixA=*matrixB* returns **1** if every comparison is true; it returns **0** if any comparison is false.

`matrixA ≠ matrixB` returns **1** if at least one comparison is false; it returns **0** if no comparison is false.

| | |
|-----|--|
| [A] | $\begin{bmatrix} 1 & 2 & 3 \\ 3 & 2 & 1 \end{bmatrix}$ |
| [B] | $\begin{bmatrix} 3 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix}$ |

| | |
|-----------|---|
| [A] = [B] | 0 |
| [A] ≠ [B] | 1 |

iPart(, fPart(, int(

`iPart(` (integer part), `fPart(` (fractional part), and `int(` (greatest integer) are on the **MATH NUM** menu.

`iPart(` returns a matrix containing the integer part of each element of *matrix*.

`fPart(` returns a matrix containing the fractional part of each element of *matrix*.

`int(` returns a matrix containing the greatest integer of each element of *matrix*.

`iPart(matrix)`

`fPart(matrix)`

`int(matrix)`

| | |
|-----|---|
| [D] | $\begin{bmatrix} 1.25 & 3.333 \\ 100.5 & 47.15 \end{bmatrix}$ |
|-----|---|

| | |
|------------|--|
| iPart([D]) | $\begin{bmatrix} 1 & 3 \\ 100 & 47 \end{bmatrix}$ |
| fPart([D]) | $\begin{bmatrix} .25 & .333 \\ .5 & .15 \end{bmatrix}$ |

Using the MATRIX MATH Operations

MATRIX MATH Menu

To display the MATRIX MATH menu, press **2nd [MATRIX] ▶**.

NAMES MATH EDIT

| | |
|---------------|---|
| 1: det(| Calculates the determinant. |
| 2: T | Transposes the matrix. |
| 3: dim(| Returns the matrix dimensions. |
| 4: Fill(| Fills all elements with a constant. |
| 5: identity(| Returns the identity matrix. |
| 6: randM(| Returns a random matrix. |
| 7: augment(| Appends two matrices. |
| 8: Matr►list(| Stores a matrix to a list. |
| 9: List►matr(| Stores a list to a matrix. |
| 0: cumSum(| Returns the cumulative sums of a matrix. |
| A: ref(| Returns the row-echelon form of a matrix. |
| B: rref(| Returns the reduced row-echelon form. |
| C: rowSwap(| Swaps two rows of a matrix. |
| D: row+(| Adds two rows; stores in the second row. |
| E: *row(| Multiplies the row by a number. |
| F: *row+(| Multiplies the row, adds to the second row. |

det(

det((determinant) returns the determinant (a real number) of a square *matrix*.

det(*matrix*)

T (Transpose)

T (transpose) returns a matrix in which each element (row, column) is swapped with the corresponding element (column, row) of *matrix*.

*matrix***T**

$$\begin{bmatrix} [A] & \begin{bmatrix} [1 & 2 & 3] \\ [3 & 2 & 1] \end{bmatrix} \end{bmatrix} \quad \begin{bmatrix} [A]^T & \begin{bmatrix} [1 & 3] \\ [2 & 2] \\ [3 & 1] \end{bmatrix} \end{bmatrix}$$

Accessing Matrix Dimensions with dim(

dim((dimension) returns a list containing the dimensions (*{rows columns}*) of *matrix*.

dim(*matrix*)

Note: **dim(*matrix*)** → **Ln:Ln(1)** returns the number of rows. **dim(*matrix*)** → **Ln:Ln(2)** returns the number of columns.

```
dim([[2,7,1][-8,  
3,11])  
(2 3)
```

```
dim([[2,7,1][-8,  
3,11])→L1:L1(1)  
2
```

Creating a Matrix with dim(

Use **dim(** with **STO►** to create a new *matrixname* of dimensions *rows* × *columns* with 0 as each element.

{*rows*,*columns*}→dim(*matrixname*)

```
(2,2)→dim([E])  
(2 2)  
[E]  
[[0 0]  
 [0 0]]
```

Redimensioning a Matrix with dim(

Use **dim(** with **STO►** to redimension an existing *matrixname* to dimensions *rows* × *columns*. The elements in the old *matrixname* that are within the new dimensions are not changed. Additional created elements are zeros. Matrix elements that are outside the new dimensions are deleted.

{*rows*,*columns*}→dim(*matrixname*)

Fill(

Fill(stores *value* to every element in *matrixname*.

Fill(*value,matrixname*)

```
Fill(5, [E])      Done  
[E]      [[5 5]  
           [5 5]]
```

identity(

identity(returns the identity matrix of *dimension* rows \times *dimension* columns.

identity(*dimension*)

randM(

randM((create random matrix) returns a *rows* \times *columns* random matrix of integers ≥ -9 and ≤ 9 . The seed value stored to the **rand** function controls the values (Chapter 2).

randM(*rows,columns*)

```
0→rand:randM(2,2  
)  
[[0 -7]  
 [8 1]]
```

augment(

augment(appends *matrixA* to *matrixB* as new columns. *matrixA* and *matrixB* both must have the same number of rows.

augment(*matrixA*,*matrixB*)

```
[[1,2][3,4]]→[A]
[[5,6][7,8]]→[B]
]::augment([A],[B])
)
[[1 2 5 6]
 [3 4 7 8]]
```

Mat►list(

Mat►list((*matrix* stored to *list*) fills each *listname* with elements from each column in *matrix*. **Mat►list(** ignores extra *listname* arguments. Likewise, **Mat►list(** ignores extra *matrix* columns.

Mat►list(*matrix*,*listnameA*,...,*listname n*)

| | | | | |
|--|----------------------|----------------|----------------|-------|
| [A] | [[1 2 3] [4 5 6]] | → | L ₁ | (1 4) |
| Mat►list([A],L ₁ , ,L ₂ ,L ₃) | Done | L ₂ | (2 5) | |
| | | L ₃ | (3 6) | |

Mat►list(also fills a *listname* with elements from a specified *column#* in *matrix*. To fill a list with a specific column from *matrix*, you must enter *column#* after *matrix*.

Mat \blacktriangleright list(*matrix, column#, listname*)

```
[A]
[[1 2 3]
 [4 5 6]]
Matr $\blacktriangleright$ list([A],3,
L1)
Done
```

→

L1

C3 L3

List \blacktriangleright matr()

List \blacktriangleright matr((*lists stored to matrix*) fills *matrixname* column by column with the elements from each *list*. If dimensions of all *lists* are not equal, **List \blacktriangleright matr(** fills each extra *matrixname* row with **0**. Complex lists are not valid.

List \blacktriangleright matr(*listA,...,list n,matrixname*)

```
(1,2,3)  $\rightarrow$  LX
          {1 2 3}
(4,5,6)  $\rightarrow$  LY
          {4 5 6}
(7,8,9)  $\rightarrow$  LB
          {7 8 9}
```

→

List \blacktriangleright matr(LX, LY,
LB, [C])

Done

[C]

[[1 4 7]
 [2 5 8]
 [3 6 9]]

cumSum(

cumSum(returns cumulative sums of the elements in *matrix*, starting with the first element. Each element is the cumulative sum of the column from top to bottom.

cumSum(*matrix*)

| | |
|-----|---|
| [D] | $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$ |
|-----|---|

| | |
|-------------|--|
| cumSum([D]) | $\begin{bmatrix} 1 & 2 & 1 \\ 4 & 6 & 1 \\ 9 & 12 & 1 \end{bmatrix}$ |
|-------------|--|

Row Operations

MATRIX MATH menu items **A** through **F** are row operations. You can use a row operation in an expression. Row operations do not change *matrix* in memory. You can enter all row numbers and values as expressions. You can select the matrix from the MATRIX NAMES menu.

ref(, rref(

ref((row-echelon form) returns the row-echelon form of a real *matrix*. The number of columns must be greater than or equal to the number of rows.

ref(*matrix*)

rref((reduced row-echelon form) returns the reduced row-echelon form of a real *matrix*. The number of columns must be greater than or equal to the number of rows.

rref(*matrix*)

| |
|--|
| [B] |
| $\begin{bmatrix} 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$ |

| |
|---|
| ref([B]) |
| $\begin{bmatrix} 1 & 1.142857143... \\ 0 & 1 \end{bmatrix}$ |
| rref([B]) |
| $\begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & 2 \end{bmatrix}$ |

rowSwap(

rowSwap(returns a matrix. It swaps *rowA* and *rowB* of *matrix*.

rowSwap(*matrix*,*rowA*,*rowB*)

| |
|--|
| [F] |
| $\begin{bmatrix} 2 & 3 & 6 & 9 \\ 5 & 8 & 4 & ? \\ 2 & 5 & 1 & 0 \\ 6 & 3 & 8 & 5 \end{bmatrix}$ |

| |
|--|
| rowSwap([F],2,4) |
| $\begin{bmatrix} 2 & 3 & 6 & 9 \\ 6 & 3 & 8 & 5 \\ 2 & 5 & 1 & 0 \\ 5 & 8 & 4 & ? \end{bmatrix}$ |

row+(

row+((row addition) returns a matrix. It adds *rowA* and *rowB* of *matrix* and stores the results in *rowB*.

row+(*matrix*,*rowA*,*rowB*)

| |
|--|
| $\begin{bmatrix} 2 & 5 & 7 \\ 8 & 9 & 4 \end{bmatrix}$ |
| $\rightarrow [D]$ |
| $\begin{bmatrix} 2 & 5 & 7 \\ 8 & 9 & 4 \end{bmatrix}$ |

| |
|---|
| row+([D],1,2) |
| $\begin{bmatrix} 2 & 5 & 7 \\ 10 & 14 & 11 \end{bmatrix}$ |

*row(

***row(** (row multiplication) returns a matrix. It multiplies *row* of *matrix* by *value* and stores the results in *row*.

*row(*value,matrix,row*)

*row+(

***row+(** (row multiplication and addition) returns a matrix. It multiplies *rowA* of *matrix* by *value*, adds it to *rowB*, and stores the results in *rowB*.

*row+(*value,matrix,rowA,rowB*)

$\begin{bmatrix} [[1, 2, 3] [4, 5, 6]] \\ \rightarrow [E] \\ [[1 & 2 & 3] \\ [4 & 5 & 6]] \end{bmatrix}$

$\begin{bmatrix} *row+(3, [E], 1, 2) \\ [[1 & 2 & 3] \\ [7 & 11 & 15]] \end{bmatrix}$

Chapter 11:

Lists

Getting Started: Generating a Sequence

Getting Started is a fast-paced introduction. Read the chapter for details.

Calculate the first eight terms of the sequence $1/A^2$. Store the results to a user-created list. Then display the results in fraction form. Begin this example on a blank line on the home screen.

1. Press **2nd** [LIST] **►** to display the LIST OPS menu.



2. Press **5** to select **5:seq(**, which pastes **seq(** to the current cursor location.
3. Press **1** **÷** **[ALPHA]** [A] **[x^2]** **,** **[ALPHA]** [A] **,** **1** **,** **8** **,** **1** **)** to enter the sequence.



4. Press **[STO►]**, and then press **[2nd] [ALPHA]** to turn on alpha-lock. Press **[s] [E] [Q]**, and then press **[ALPHA]** to turn off alpha-lock. Press **1** to complete the list name.
5. Press **[ENTER]** to generate the list and store it in **SEQ1**. The list is displayed on the home screen. An ellipsis (...) indicates that the list continues beyond the viewing window. Press **►** repeatedly (or press and hold **►**) to scroll the list and view all the list elements.
6. Press **[2nd] [LIST]** to display the **LIST NAMES** menu. Press **7** to select **7:seq(** to paste **LSEQ1** to the current cursor location. (If **SEQ1** is not item **7** on your **LIST NAMES** menu, move the cursor to **SEQ1** before you press **[ENTER]**.)

```
seq(1/A^2,A,1,8,1  
→SEQ1  
{1 .25 .1111111...  
█
```

| | | |
|------------------|-----|------|
| NAMES | OPS | MATH |
| 1 | | |
| 2:L ₂ | | |
| 3:L ₃ | | |
| 4:L ₄ | | |
| 5:L ₅ | | |
| 6:L ₆ | | |
| 7:SEQ1 | | |

7. Press **MATH** to display the **MATH** menu. Press **1** to select **1:Frac**, which pastes **►Frac** to the current cursor location.
8. Press **ENTER** to show the sequence in fraction form. Press **▶** repeatedly (or press and hold **▶**) to scroll the list and view all the list elements.

```
seq(1/A^2,A,1,8,1  
)→SEQ1  
{1,.25,.1111111...  
LSEQ1►Frac  
{1 1/4 1/9 1/16...  
█
```

Naming Lists

Using TI-83 Plus List Names L₁ through L₆

The TI-83 Plus has six list names in memory: L₁, L₂, L₃, L₄, L₅, and L₆. The list names L₁ through L₆ are on the keyboard above the numeric keys [1] through [6]. To paste one of these names to a valid screen, press [2nd], and then press the appropriate key. L₁ through L₆ are stored in stat list editor columns 1 through 6 when you reset memory.

Creating a List Name on the Home Screen

To create a list name on the home screen, follow these steps.

1. Press [2nd] [{}, enter one or more list elements, and then press [2nd] [)]. Separate list elements with commas. List elements can be real numbers, complex numbers, or expressions.

[{1, 2, 3, 4}]

2. Press [STO►].
3. Press [ALPHA] [*letter from A to Z or θ*] to enter the first letter of the name.

4. Enter zero to four letters, θ , or numbers to complete the name.

`(1,2,3,4)→TEST`

5. Press **ENTER**. The list is displayed on the next line. The list name and its elements are stored in memory. The list name becomes an item on the **LIST NAMES** menu.

The left side of the screen shows the command `(1,2,3,4)→TEST` with the elements `(1 2 3 4)` highlighted. The right side shows the **LIST NAMES** menu with the following options:

| | | |
|---------|-----|------|
| 1: SEQ1 | OPS | MATH |
| 2: T123 | | |
| 3: TEST | | |

Note: If you want to view a user-created list in the stat list editor, you must store it in the stat list editor (Chapter 12).

You also can create a list name in these four places.

- At the **Name=** prompt in the stat list editor
- At an **Xlist:, Ylist:, or Data List:** prompt in the stat plot editor
- At a **List:, List1:, List2:, Freq:, Freq1:, Freq2:, XList:, or YList:** prompt in the inferential stat editors
- On the home screen using **SetUpEditor**

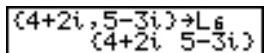
You can create as many list names as your TI-83 Plus memory has space to store.

Storing and Displaying Lists

Storing Elements to a List

You can store list elements in either of two ways.

- Use braces and **STO►** on the home screen.



(4+2i, 5-3i)→L₆
(4+2i 5-3i)

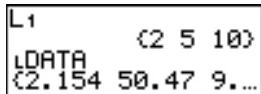
- Use the stat list editor (Chapter 12).

The maximum dimension of a list is 999 elements.

Tip: When you store a complex number to a list, the entire list is converted to a list of complex numbers. To convert the list to a list of real numbers, display the home screen, and then enter **real(listname)→listname**.

Displaying a List on the Home Screen

To display the elements of a list on the home screen, enter the name of the list (preceded by **L**, if necessary, and then press **ENTER**). An ellipsis indicates that the list continues beyond the viewing window. Press **►** repeatedly (or press and hold **►**) to scroll the list and view all the list elements.



L₁ C2 5 100
LDATA C2.154 50.47 9....

Copying One List to Another

To copy a list, store it to another list.

```
LTEST {1 2 3 4}  
LTEST→TEST2  
{1 2 3 4}
```

Accessing a List Element

You can store a value to or recall a value from a specific list *element*. You can store to any element within the current list dimension or one element beyond.

listname(element)

```
{1,2,3}→L3  
{1 2 3}  
4→L3(4):L3  
(1 2 3 4)  
L3(2)  
2
```

Deleting a List from Memory

To delete lists from memory, including L₁ through L₆, use the **MEMORY MANAGEMENT/DELETE** secondary menu (Chapter 18). Resetting memory restores L₁ through L₆. Removing a list from the stat list editor does not delete it from memory.

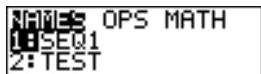
Using Lists in Graphing

You can use lists to graph a family of curves (Chapter 3).

Entering List Names

Using the LIST NAMES Menu

To display the **LIST NAMES** menu, press **2nd [LIST]**. Each item is a user-created list name. **LIST NAMES** menu items are sorted automatically in alphanumerical order. Only the first 10 items are labeled, using **1** through **9**, then **0**. To jump to the first list name that begins with a particular alpha character or θ , press **ALPHA [letter from A to Z or θ]**.

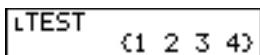


Tip: From the top of a menu, press **▼** to move to the bottom. From the bottom, press **▲** to move to the top.

Note: The **LIST NAMES** menu omits list names **L1** through **L6**. Enter **L1** through **L6** directly from the keyboard.

When you select a list name from the **LIST NAMES** menu, the list name is pasted to the current cursor location.

- The list name symbol **L** precedes a list name when the name is pasted where non-list name data also is valid, such as the home screen.

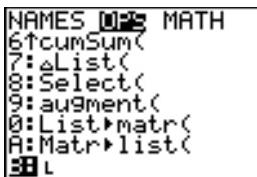


- The `L` symbol does not precede a list name when the name is pasted where a list name is the only valid input, such as the stat list editor's **Name=** prompt or the stat plot editor's **XList:** and **YList:** prompts.

Entering a User-Created List Name Directly

To enter an existing list name directly, follow these steps.

- Press **2nd** [LIST] **►** to display the **LIST OPS** menu.
- Select **B:L**, which pastes `L` to the current cursor location. `L` is not always necessary.



Note: You also can paste `L` to the current cursor location from the **CATALOG** (Chapter 15).

- Enter the characters that comprise the list name.



Attaching Formulas to List Names

Attaching a Formula to a List Name

You can attach a formula to a list name so that each list element is a result of the formula. When executed, the attached formula must resolve to a list.

When anything in the attached formula changes, the list to which the formula is attached is updated automatically.

- When you edit an element of a list that is referenced in the formula, the corresponding element in the list to which the formula is attached is updated.
- When you edit the formula itself, all elements in the list to which the formula is attached are updated.

For example, the first screen below shows that elements are stored to **L₃**, and the formula **L₃+10** is attached to the list name **LADD10**. The quotation marks designate the formula to be attached to **LADD10**. Each element of **LADD10** is the sum of an element in **L₃** and 10.

```
(1,2,3)→L3
          {1 2 3}
" L3+10 " → LADD10
L3+10
LADD10
          {11 12 13}
```

The next screen shows another list, **L4**. The elements of **L4** are the sum of the same formula that is attached to **L3**. However, quotation marks are not entered, so the formula is not attached to **L4**.

On the next line, **-6→L3(1):L3** changes the first element in **L3** to **-6**, and then redisplays **L3**.

```
L3+10→L4
{11 12 13}
-6→L3(1):L3
{-6 2 3}
```

The last screen shows that editing **L3** updated **LADD10**, but did not change **L4**. This is because the formula **L3+10** is attached to **LADD10**, but it is not attached to **L4**.

```
LADD10
{4 12 13}
L4
{11 12 13}
```

Note: To view a formula that is attached to a list name, use the stat list editor (Chapter 12).

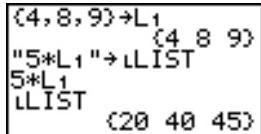
Attaching a Formula to a List on the Home Screen or in a Program

To attach a formula to a list name from a blank line on the home screen or from a program, follow these steps.

1. Press **[ALPHA] [\wedge]**, enter the formula (which must resolve to a list), and press **[ALPHA] [\wedge]** again.

Note: When you include more than one list name in a formula, each list must have the same dimension.

2. Press **[STO \blacktriangleright]**.
3. Enter the name of the list to which you want to attach the formula.
 - Press **[2nd]**, and then enter a TI-83 Plus list name **L1** through **L6**.
 - Press **[2nd] [LIST]** and select a user-created list name from the **LIST NAMES** menu.
 - Enter a user-created list name directly using **L**.
4. Press **[ENTER]**.



The image shows a screenshot of the TI-83 Plus calculator's stat list editor. The screen displays a list of formulas attached to list L1. The formulas are:
1. $\{4, 8, 9\} \rightarrow L_1$ (with a formula-lock symbol next to L1)
2. $\{4, 8, 9\}$
3. $"5*L_1" \rightarrow LLIST$
4. $5*L_1$
5. $LLIST$
The final result of the attached formulas is shown as a list:
 $\{20, 40, 45\}$

Note: The stat list editor displays a formula-lock symbol next to each list name that has an attached formula. Chapter 12 describes how to use the stat list editor to attach formulas to lists, edit attached formulas, and detach formulas from lists.

Detaching a Formula from a List

You can detach (clear) an attached formula from a list in several ways.

For example:

- Enter " $\text{""} \rightarrow \text{listname}$ " on the home screen.
- Edit any element of a list to which a formula is attached.
- Use the stat list editor (Chapter 12).
- Use **ClrList** or **ClrAllList** to detach a formula from a list (Chapter 18).

Using Lists in Expressions

Using a List in an Expression

You can use lists in an expression in any of three ways. When you press **[ENTER]**, any expression is evaluated for each list element, and a list is displayed.

- Use **L₁–L₆** or any user-created list name in an expression.

The calculator screen shows the following sequence of inputs and outputs:
1. The command `(2,5,10)→L1` is entered.
2. The list `{2 5 10}` is displayed.
3. The command `20/L1` is entered.
4. The result `{10 4 2}` is displayed.

- Enter the list elements directly.

The calculator screen shows the following sequence of inputs and outputs:
1. The command `20/{2,5,10}` is entered.
2. The list `{10 4 2}` is displayed.

- Use **[2nd] [RCL]** to recall the contents of the list into an expression at the cursor location (Chapter 1).

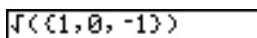
The calculator screen shows the following sequence of inputs and outputs:
1. The command `Rcl L1` is entered.
2. An arrow points to the result `{(2,5,10)2} {4 25 100}`.

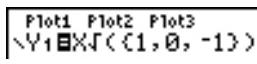
Note: You must paste user-created list names to the **Rcl** prompt by selecting them from the **LIST NAMES** menu. You cannot enter them directly using **L**.

Using Lists with Math Functions

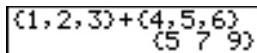
You can use a list to input several values for some math functions. Other chapters and Appendix A specify whether a list is valid. The function is evaluated for each list element, and a list is displayed.

- When you use a list with a function, the function must be valid for every element in the list. In graphing, an invalid element, such as -1 in $\sqrt{\{1, 0, -1\}}$, is ignored.

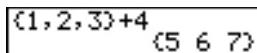
 This returns an error.

 This graphs $x*\sqrt{1}$ and $x*\sqrt{0}$, but skips $x*\sqrt{-1}$.

- When you use two lists with a two-argument function, the dimension of each list must be the same. The function is evaluated for corresponding elements.

 $\{1, 2, 3\} + \{4, 5, 6\} = \{5, 7, 9\}$

- When you use a list and a value with a two-argument function, the value is used with each element in the list.

 $\{1, 2, 3\} + 4 = \{5, 6, 7\}$

LIST OPS Menu

LIST OPS Menu

To display the LIST OPS menu, press **[2nd] [LIST]** ▶.

NAMES OPS MATH

| | |
|---------------|--|
| 1: SortA(| Sorts lists in ascending order. |
| 2: SortD(| Sorts lists in descending order. |
| 3: dim(| Sets the list dimension. |
| 4: Fill(| Fills all elements with a constant. |
| 5: seq(| Creates a sequence. |
| 6: cumSum(| Returns a list of cumulative sums. |
| 7: ΔList(| Returns difference of successive elements. |
| 8: Select(| Selects specific data points. |
| 9: augment(| Concatenates two lists. |
| 0: List►matr(| Stores a list to a matrix. |
| A: Matr►list(| Stores a matrix to a list. |
| B: L | Designates the list-name data type. |

SortA(, SortD(

SortA((sort ascending) sorts list elements from low to high values.

SortD((sort descending) sorts list elements from high to low values.

Complex lists are sorted based on magnitude (modulus).

With one list, **SortA(** and **SortD(** sort the elements of *listname* and update the list in memory.

SortA(*listname*)

```
(5,6,4)→L3
      {5 6 4}
SortA(L3)
      Done
L3
      {4 5 6}
```

SortD(*listname*)

```
SortD(L3)
      Done
L3
      {6 5 4}
```

With two or more lists, **SortA(** and **SortD(** sort *keylistname*, and then sort each *dependlist* by placing its elements in the same order as the corresponding elements in *keylistname*. All lists must have the same dimension.

SortA(*keylistname,dependlist1[,dependlist2,...,dependlist n]*)

SortD(*keylistname,dependlist1[,dependlist2,...,dependlist n]*)

```
(5,6,4)→L4
      {5 6 4}
(1,2,3)→L5
      {1 2 3}
```

```
SortA(L4,L5)
      Done
L4
      {4 5 6}
L5
      {3 1 2}
```

Note: In the example, **5** is the first element in **L4**, and **1** is the first element in **L5**. After **SortA(L4,L5)**, **5** becomes the second element of **L4**, and likewise, **1** becomes the second element of **L5**.

Note: **SortA(** and **SortD(** are the same as **SortA(** and **SortD(** on the **STAT EDIT** menu (Chapter 12).

Using dim(to Find List Dimensions

dim((dimension) returns the length (number of elements) of *list*.

dim(*list*)

```
dim({1,3,5,7}) 4
```

Using dim(to Create a List

You can use **dim(** with **STO►** to create a new *listname* with dimension *length* from 1 to 999. The elements are zeros.

length→**dim(*listname*)**

```
3→dim(Lz)      3  
Lz          {0 0 0}
```

Using dim(to Redimension a List

You can use **dim** with **STO►** to redimension an existing *listname* to dimension *length* from 1 to 999.

- The elements in the old *listname* that are within the new dimension are not changed.
- Extra list elements are filled by **0**.
- Elements in the old list that are outside the new dimension are deleted.

length→**dim**(*listname*)

| | |
|------------------------|-----------|
| (4,8,6)→L ₁ | (4 8 6) |
| 4→dim(L ₁) | 4 |
| L ₁ | (4 8 6 0) |

| | |
|------------------------|---------|
| 3→dim(L ₁) | 3 |
| L ₁ | (4 8 6) |

Fill(

Fill(replaces each element in *listname* with *value*.

Fill(*value*,*listname*)

| | |
|-------------------------|---------|
| (3,4,5)→L ₃ | (3 4 5) |
| Fill(8,L ₃) | Done |
| L ₃ | (8 8 8) |

| | |
|----------------------------|------------------|
| Fill(4+3i,L ₃) | Done |
| L ₃ | (4+3i 4+3i 4+3i) |

Note: **dim(** and **Fill(** are the same as **dim(** and **Fill(** on the **MATRIX MATH** menu (Chapter 10).

seq(

seq((sequence) returns a list in which each element is the result of the evaluation of *expression* with regard to *variable* for the values ranging from *begin* to *end* at steps of *increment*. *variable* need not be defined in memory. *increment* can be negative; the default value for *increment* is 1. **seq(** is not valid within *expression*. Complex lists are not valid.

seq(expression,variable,begin,end[,increment])

```
seq(A^2,A,1,11,3)
{1 16 49 100}
```

cumSum(

cumSum((cumulative sum) returns the cumulative sums of the elements in *list*, starting with the first element. *list* elements can be real or complex numbers.

cumSum(list)

```
cumSum({1,2,3,4,
5})
{1 3 6 10 15}
```

ΔList(

ΔList(returns a list containing the differences between consecutive elements in *list*. **ΔList** subtracts the first element in *list* from the second element, subtracts the second element from the third, and so on. The list of differences is always one element shorter than the original *list*. *list* elements can be a real or complex numbers.

ΔList(list)

```
{20,30,45,70}→L0
IST
{20 30 45 70}
ΔList({IST})
{10 15 25}
```

Select(

Select(selects one or more specific data points from a scatter plot or xyLine plot (only), and then stores the selected data points to two new lists, *xlistname* and *ylistname*. For example, you can use **Select(** to select and then analyze a portion of plotted CBL 2™/CBL™ or CBR™ data.

Select(*xlistname*,*ylistname*)

Note: Before you use **Select(**, you must have selected (turned on) a scatter plot or xyLine plot. Also, the plot must be displayed in the current viewing window.

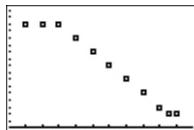
Before Using Select(

Before using **Select(**, follow these steps.

1. Create two list names and enter the data.
2. Turn on a stat plot, select $\text{L}\cdot\text{C}$ (scatter plot) or $\text{L}\cdot\text{L}$ (xyLine), and enter the two list names for **Xlist:** and **Ylist:** (Chapter 12).
3. Use **ZoomStat** to plot the data (Chapter 3).

```
{1,2,3,4,5,6,7,8  
{9,9,5,10}→DIST  
{1,2,3,4,5,6,7...  
{15,15,15,13,11,  
9,7,5,3,2,23→TIME  
E  
{15 15 15 13 11...
```

```
Plot1 Plot2 Plot3  
On Off  
Type:     
Xlist:DIST  
Ylist:TIME  
Mark:  
```



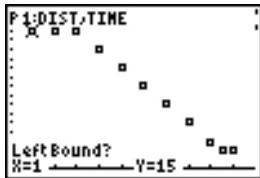
Using Select(to Select Data Points from a Plot

To select data points from a scatter plot or xyLine plot, follow these steps.

1. Press **2nd** [LIST] **►** **8** to select **8:Select(** from the **LIST OPS** menu. **Select(** is pasted to the home screen.
2. Enter *xlistname*, press **,**, enter *ylistname*, and then press **)** to designate list names into which you want the selected data to be stored.

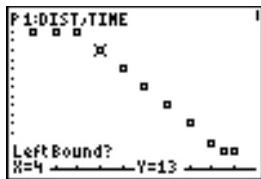
```
Select(L1,L2)
```

3. Press **ENTER**. The graph screen is displayed with **Left Bound?** in the bottom-left corner.

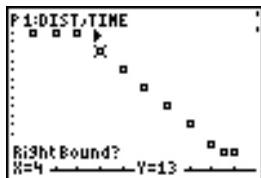


4. Press **▲** or **▼** (if more than one stat plot is selected) to move the cursor onto the stat plot from which you want to select data points.

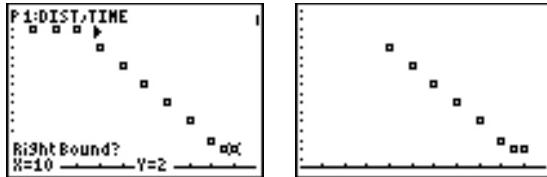
5. Press \blacktriangleleft and \triangleright to move the cursor to the stat plot data point that you want as the left bound.



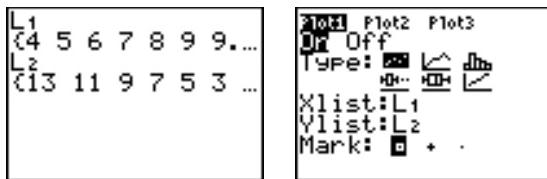
6. Press **ENTER**. A \triangleright indicator on the graph screen shows the left bound. **Right Bound?** is displayed in the bottom-left corner.



7. Press \blacktriangleleft or \triangleright to move the cursor to the stat plot point that you want for the right bound, and then press **ENTER**.



The x-values and y-values of the selected points are stored in *xlistname* and *ylistname*. A new stat plot of *xlistname* and *ylistname* replaces the stat plot from which you selected data points. The list names are updated in the stat plot editor.



Note: The two new lists (*xlistname* and *ylistname*) will include the points you select as left bound and right bound. Also, *left-bound x-value* \leq *right-bound x-value* must be true.

augment(

augment(concatenates the elements of *listA* and *listB*. The list elements can be real or complex numbers.

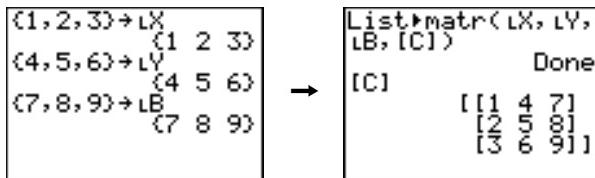
augment(*listA*,*listB*)

```
{1,17,21}→L3
{1 17 21}
augment(L3,{25,3
0,41})
{1 17 21 25 30 ...}
```

List►matr(

List►matr((lists stored to matrix) fills *matrixname* column by column with the elements from each list. If the dimensions of all lists are not equal, then **List►matr(** fills each extra *matrixname* row with **0**. Complex lists are not valid.

List►matr(list1,list2, . . . ,list n,matrixname)



Mat►list(

Mat►list((matrix stored to lists) fills each *listname* with elements from each column in *matrix*. If the number of *listname* arguments exceeds the number of columns in *matrix*, then **Mat►list(** ignores extra *listname* arguments. Likewise, if the number of columns in *matrix* exceeds the number of *listname* arguments, then **Mat►list(** ignores extra *matrix* columns.

Mat►list(matrix,listname1,listname2, . . . ,listname n)

| | | | | | | | | |
|--|-------|---|----------------|-------|----------------|-------|----------------|-------|
| <pre>[A] [[1 2 3] [4 5 6]] Matr→list([A],L1, L2,L3) Done</pre> | | <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">L₁</td><td style="padding: 2px;">(1 4)</td></tr> <tr><td style="padding: 2px;">L₂</td><td style="padding: 2px;">(2 5)</td></tr> <tr><td style="padding: 2px;">L₃</td><td style="padding: 2px;">(3 6)</td></tr> </table> | L ₁ | (1 4) | L ₂ | (2 5) | L ₃ | (3 6) |
| L ₁ | (1 4) | | | | | | | |
| L ₂ | (2 5) | | | | | | | |
| L ₃ | (3 6) | | | | | | | |

Matrlist(also fills a *listname* with elements from a specified *column#* in *matrix*. To fill a list with a specific column from *matrix*, you must enter a *column#* after *matrix*.

Matrlist(*matrix*,*column#*,*listname*)

| | | | | |
|--|-------|---|----------------|-------|
| <pre>[A] [[1 2 3] [4 5 6]] Matr→list([A],3, L1) Done</pre> | | <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">L₁</td><td style="padding: 2px;">(3 6)</td></tr> </table> | L ₁ | (3 6) |
| L ₁ | (3 6) | | | |

↳ preceding one to five characters identifies those characters as a user-created *listname*. *listname* may comprise letters, θ, and numbers, but it must begin with a letter from A to Z or θ.

↳ *listname*

Generally, ↳ must precede a user-created list name when you enter a user-created list name where other input is valid, for example, on the home screen. Without the ↳, the TI-83 Plus may misinterpret a user-created list name as implied multiplication of two or more characters.

`L` need not precede a user-created list name where a list name is the only valid input, for example, at the **Name=** prompt in the stat list editor or the **Xlist:** and **Ylist:** prompts in the stat plot editor. If you enter `L` where it is not necessary, the TI-83 Plus will ignore the entry.

LIST MATH Menu

LIST MATH Menu

To display the LIST MATH menu, press **2nd [LIST]** .

| NAMES OPS | MATH |
|-------------|---------------------------------------|
| 1:min(| Returns minimum element of a list. |
| 2:max(| Returns maximum element of a list. |
| 3:mean(| Returns mean of a list. |
| 4:median(| Returns median of a list. |
| 5:sum(| Returns sum of elements in a list. |
| 6:prod(| Returns product of elements in list. |
| 7:stdDev(| Returns standard deviation of a list. |
| 8:variance(| Returns the variance of a list. |

min(, max(

min((minimum) and **max(** (maximum) return the smallest or largest element of *listA*. If two lists are compared, it returns a list of the smaller or larger of each pair of elements in *listA* and *listB*. For a complex list, the element with smallest or largest magnitude (modulus) is returned.

min(*listA[,listB]*)
max(*listA[,listB]*)

```
min({1,2,3}, {3,2,  
,1})  
      {1 2 1}  
max({1,2,3}, {3,2,  
,1})  
      {3 2 3}
```

Note: **min(** and **max(** are the same as **min(** and **max(** on the **MATH NUM** menu.

mean(), median()

mean(returns the mean value of *list*. **median(** returns the median value of *list*. The default value for *freqlist* is 1. Each *freqlist* element counts the number of consecutive occurrences of the corresponding element in *list*. Complex lists are not valid.

mean(*list[,freqlist]*)
median(*list[,freqlist]*)

```
mean({1,2,3}, {3,  
2,1})  
      1.666666667  
median({1,2,3})  
      2
```

sum(, prod(

sum((summation) returns the sum of the elements in *list*. *start* and *end* are optional; they specify a range of elements. *list* elements can be real or complex numbers.

prod(returns the product of all elements of *list*. *start* and *end* elements are optional; they specify a range of list elements. *list* elements can be real or complex numbers.

sum(*list[,start,end]*)

| | |
|-------------|--------------|
| L1 | {1 2 5 8 10} |
| sum(L1) | 26 |
| sum(L1,3,5) | 23 |

prod(*list[,start,end]*)

| | |
|--------------|--------------|
| L1 | {1 2 5 8 10} |
| Prod(L1) | 800 |
| Prod(L1,3,5) | 400 |

Sums and Products of Numeric Sequences

You can combine **sum(** or **prod(** with **seq(** to obtain:

$$\sum_{x=lower}^{upper} expression(x)$$

$$\prod_{x=lower}^{upper} expression(x)$$

To evaluate $\sum 2^{(N-1)}$ from N=1 to 4:

```
sum(seq(2^(N-1),  
N,1,4,1))  
15
```

stdDev(, variance(

stdDev(returns the standard deviation of the elements in *list*. The default value for *freqlist* is 1. Each *freqlist* element counts the number of consecutive occurrences of the corresponding element in *list*. Complex lists are not valid.

variance(returns the variance of the elements in *list*. The default value for *freqlist* is 1. Each *freqlist* element counts the number of consecutive occurrences of the corresponding element in *list*. Complex lists are not valid.

stdDev(*list[,freqlist]*)

```
stdDev({1,2,5,-6  
,3,-2})  
3.937003937
```

variance(*list[,freqlist]*)

```
variance({1,2,5,  
-6,3,-2})  
15.5
```

Chapter 12: **Statistics**

Getting Started: Pendulum Lengths and Periods

Getting Started is a fast-paced introduction. Read the chapter for details.

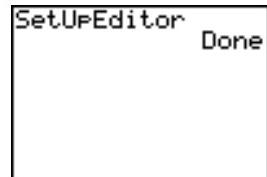
A group of students is attempting to determine the mathematical relationship between the length of a pendulum and its period (one complete swing of a pendulum). The group makes a simple pendulum from string and washers and then suspends it from the ceiling. They record the pendulum's period for each of 12 string lengths.*

| Length (cm) | Time (sec) | Length (cm) | Time (sec) |
|-------------|------------|-------------|------------|
| 6.5 | 0.51 | 24.4 | 1.01 |
| 11.0 | 0.68 | 26.6 | 1.08 |
| 13.2 | 0.73 | 30.5 | 1.13 |
| 15.0 | 0.79 | 34.3 | 1.26 |
| 18.0 | 0.88 | 37.6 | 1.28 |
| 23.1 | 0.99 | 41.5 | 1.32 |

*This example is quoted and adapted from *Contemporary Precalculus Through Applications*, by the North Carolina School of Science and Mathematics, by permission of Janson Publications, Inc., Dedham, MA. 1-800-322-MATH. © 1992. All rights reserved.

1. Press **MODE** **ENTER** to set **Func** graphing mode.
2. Press **STAT** 5 to select **5:SetUpEditor**.
SetUpEditor is pasted to the home screen.

Press **ENTER**. This removes lists from stat list editor columns 1 through **20**, and then stores lists **L1** through **L6** in columns 1 through **6**.



Note: Removing lists from the stat list editor does not delete them from memory.

3. Press **STAT** 1 to select **1>Edit** from the **STAT EDIT** menu. The stat list editor is displayed. If elements are stored in **L1** and **L2**, press **▲** to move the cursor onto **L1**, and then press **CLEAR** **ENTER** **▶** **▲** **CLEAR** **ENTER** to clear both lists. Press **◀** to move the rectangular cursor back to the first row in **L1**.
4. Press **6** **.** **5** **ENTER** to store the first pendulum string length (6.5 cm) in **L1**. The rectangular cursor moves to the next row. Repeat this step to enter each of the 12 string length values in the table.

| L1 | L2 | L3 | 1 |
|----------------|-------|-------|---|
| ----- | ----- | ----- | |
| L1(1) = | | | |

| L1 | L2 | L3 | 1 |
|-----------------|----|----|---|
| 24.4 | | | |
| 26.6 | | | |
| 30.5 | | | |
| 34.3 | | | |
| 37.6 | | | |
| 41.5 | | | |
| L1(13) = | | | |

5. Press \blacktriangleright to move the rectangular cursor to the first row in L₂.

Press $\text{.} \quad 51 \text{ [ENTER]}$ to store the first time measurement (.51 sec) in L₂. The rectangular cursor moves to the next row. Repeat this step to enter each of the 12 time values in the table.

| L1 | L2 | L3 | z |
|----------|------|----|---|
| 24.4 | 1.01 | | |
| 26.6 | 1.08 | | |
| 30.5 | 1.13 | | |
| 34.3 | 1.26 | | |
| 37.6 | 1.28 | | |
| 41.5 | 1.32 | | |
| ----- | | | |
| L2(13) = | | | |

6. Press Y= to display the Y= editor.

If necessary, press CLEAR to clear the function Y₁. As necessary, press [A] , [ENTER] , and \blacktriangleright to turn off Plot1, Plot2, and Plot3 from the top line of the Y= editor (Chapter 3). As necessary, press [B] , [C] , and [ENTER] to deselect functions.

| Plot1 | Plot2 | Plot3 |
|--|-------|-------|
| $\text{\textbackslash Y}_1 = \blacksquare$ | | |
| $\text{\textbackslash Y}_2 =$ | | |
| $\text{\textbackslash Y}_3 =$ | | |
| $\text{\textbackslash Y}_4 =$ | | |
| $\text{\textbackslash Y}_5 =$ | | |
| $\text{\textbackslash Y}_6 =$ | | |
| $\text{\textbackslash Y}_7 =$ | | |

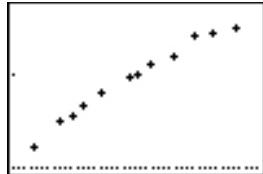
7. Press $\text{2nd} \text{ [STAT PLOT]} \text{ 1}$ to select 1:Plot1 from the STAT PLOTS menu. The stat plot editor is displayed for plot 1.

| Plot1 | Plot2 | Plot3 |
|--------------------------|----------------|----------------|
| On \blacksquare | | |
| Type: \blacksquare | \leftarrow | \rightarrow |
| Xlist: L ₁ | \blacksquare | \blacksquare |
| Ylist: L ₂ | \blacksquare | \blacksquare |
| Mark: \blacksquare + . | | |

8. Press **[ENTER]** to select **On**, which turns on plot 1. Press **▼ [ENTER]** to select **L1** (scatter plot). Press **▼ 2nd [L1]** to specify **Xlist:L1** for plot 1. Press **▼ 2nd [L2]** to specify **Ylist:L2** for plot 1. Press **▼ [ENTER]** to select **+** as the **Mark** for each data point on the scatter plot.

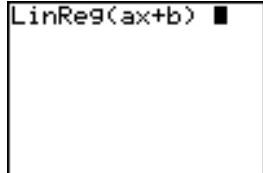


9. Press **ZOOM 9** to select **9:ZoomStat** from the **ZOOM** menu. The window variables are adjusted automatically, and plot 1 is displayed. This is a scatter plot of the time-versus-length data.



Since the scatter plot of time-versus-length data appears to be approximately linear, fit a line to the data.

10. Press **STAT ▶ 4** to select **4:LinReg(ax+b)** (linear regression model) from the **STAT CALC** menu. **LinReg(ax+b)** is pasted to the home screen.



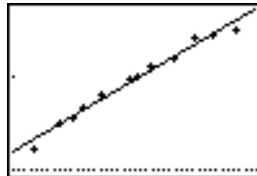
11. Press **2nd** **[L1]** **,** **2nd** **[L2]** **,**. Press **VARS** **►** **1** to display the **VARS Y-VARS FUNCTION** secondary menu, and then press **1** to select **1:Y1**. **L1**, **L2**, and **Y1** are pasted to the home screen as arguments to **LinReg(ax+b)**.

```
LinReg(ax+b) L1,  
L2,Y1■
```

12. Press **[ENTER]** to execute **LinReg(ax+b)**. The linear regression for the data in **L1** and **L2** is calculated. Values for **a** and **b** are displayed on the home screen. The linear regression equation is stored in **Y1**. Residuals are calculated and stored automatically in the list name **RESID**, which becomes an item on the **LIST NAMES** menu.

```
LinReg  
y=ax+b  
a=.0230877122  
b=.4296826236
```

13. Press **[GRAPH]**. The regression line and the scatter plot are displayed.



The regression line appears to fit the central portion of the scatter plot well. However, a residual plot may provide more information about this fit.

14. Press **STAT** 1 to select 1>Edit. The stat list editor is displayed.

Press **▶** and **◀** to move the cursor onto **L3**.

Press **2nd** [INS]. An unnamed column is displayed in column 3; **L3**, **L4**, **L5**, and **L6** shift right one column. The **Name=** prompt is displayed in the entry line, and alpha-lock is on.

15. Press **2nd** [LIST] to display the **LIST NAMES** menu.

If necessary, press **▼** to move the cursor onto the list name **RESID**.

| L1 | L2 | 3 |
|------|------|---|
| 6.5 | .51 | |
| 11 | .68 | |
| 13.2 | .73 | |
| 15 | .78 | |
| 18 | .88 | |
| 23.1 | .99 | |
| 24.4 | 1.01 | |

Name=**R**

| | | |
|----------------|-----|------|
| NAMES | OPS | MATH |
| 1 RESID | | |

16. Press **ENTER** to select **RESID** and paste it to the stat list editor's **Name=** prompt.

| L1 | L2 | 3 |
|------|------|---|
| 6.5 | .51 | |
| 11 | .68 | |
| 13.2 | .73 | |
| 15 | .78 | |
| 18 | .88 | |
| 23.1 | .99 | |
| 24.4 | 1.01 | |

Name=**RESID**█

17. Press **[ENTER]**. RESID is stored in column 3 of the stat list editor.

Press **▼** repeatedly to examine the residuals.

| L1 | L2 | RESID |
|------|------|--------|
| 6.5 | .51 | -.0698 |
| 11 | .68 | -.0036 |
| 13.2 | .73 | -.0044 |
| 15 | .78 | .014 |
| 18 | .88 | .03424 |
| 23.1 | .99 | .02689 |
| 24.4 | 1.01 | .01698 |

RESID = C - .0697527...

Notice that the first three residuals are negative. They correspond to the shortest pendulum string lengths in L1. The next five residuals are positive, and three of the last four are negative. The latter correspond to the longer string lengths in L1. Plotting the residuals will show this pattern more clearly.

18. Press **2nd [STAT PLOT]** **2** to select **2:Plot2** from the **STAT PLOTS** menu. The stat plot editor is displayed for plot 2.



19. Press **[ENTER]** to select **On**, which turns on plot 2.

Press **▼ [ENTER]** to select **□** (scatter plot). Press **▼ 2nd [L1]** to specify **Xlist:L1** for plot 2. Press **▼ [R] [E] [S] [I] [D]** (alpha-lock is on) to specify **Ylist:RESID** for plot 2. Press **▼ [ENTER]** to select **□** as the mark for each data point on the scatter plot.

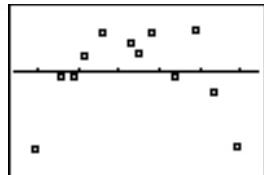


20. Press **[Y=]** to display the **Y=** editor.

Press **[** to move the cursor onto the **=** sign, and then press **[ENTER]** to deselect **Y1**. Press **[** **[ENTER]** to turn off plot 1.

| | | |
|-----------------------------|--------------|-------|
| Plot1 | Plot2 | Plot3 |
| $\text{Y}_1 = .02308771216$ | | |
| $587x + .4296826235$ | | |
| 7287 | | |
| $\text{Y}_2 =$ | | |
| $\text{Y}_3 =$ | | |
| $\text{Y}_4 =$ | | |
| $\text{Y}_5 =$ | | |

21. Press **ZOOM** **9** to select **9:ZoomStat** from the **zoom** menu. The window variables are adjusted automatically, and plot 2 is displayed. This is a scatter plot of the residuals.



Notice the pattern of the residuals: a group of negative residuals, then a group of positive residuals, and then another group of negative residuals.

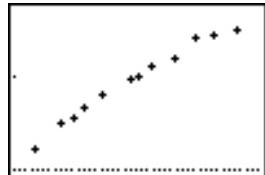
The residual pattern indicates a curvature associated with this data set for which the linear model did not account. The residual plot emphasizes a downward curvature, so a model that curves down with the data would be more accurate. Perhaps a function such as square root would fit. Try a power regression to fit a function of the form $y = a * x^b$.

22. Press **[Y=]** to display the **Y=** editor.

Press **[CLEAR]** to clear the linear regression equation from **Y1**. Press **[** **[ENTER]** to turn on plot 1. Press **[** **[ENTER]** to turn off plot 2.

| | | |
|----------------|-------|-------|
| Plot1 | Plot2 | Plot3 |
| $\text{Y}_1 =$ | | |
| $\text{Y}_2 =$ | | |
| $\text{Y}_3 =$ | | |
| $\text{Y}_4 =$ | | |
| $\text{Y}_5 =$ | | |
| $\text{Y}_6 =$ | | |
| $\text{Y}_7 =$ | | |

23. Press **ZOOM** 9 to select 9:ZoomStat from the **ZOOM** menu. The window variables are adjusted automatically, and the original scatter plot of time-versus-length data (plot 1) is displayed.



24. Press **STAT** **►** **ALPHA** [A] to select A:PwrReg from the **STAT CALC** menu. **PwrReg** is pasted to the home screen.

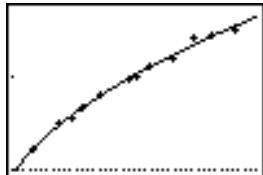
PwrReg L₁,L₂,Y₁■

Press **2nd** [L₁] **,** **2nd** [L₂] **,**. Press **VARS** **►** 1 to display the **VARS Y-VARS FUNCTION** secondary menu, and then press 1 to select 1:Y₁. L₁, L₂, and Y₁ are pasted to the home screen as arguments to **PwrReg**.

25. Press **ENTER** to calculate the power regression. Values for **a** and **b** are displayed on the home screen. The power regression equation is stored in Y₁. Residuals are calculated and stored automatically in the list name **RESID**.

PwrReg
y=a*x^b
a=.1922828621
b=.5224982852
■

26. Press **[GRAPH]**. The regression line and the scatter plot are displayed.



The new function $y=.192x^{.522}$ appears to fit the data well. To get more information, examine a residual plot.

27. Press **[Y=]** to display the **Y=** editor.

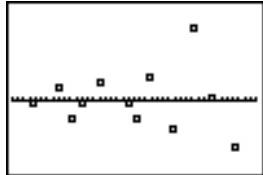
Press **[]** **[ENTER]** to deselect **Y1**.

Press **[]** **[ENTER]** to turn off plot 1. Press **[]** **[ENTER]** to turn on plot 2.

| | | |
|---------------------------------|--------------|-------|
| Plot1 | Plot2 | Plot3 |
| $\backslash Y_1 = .19228286213$ | | |
| $552X^{.5224982852}$ | | |
| 0.96 | | |
| $\backslash Y_2 =$ | | |
| $\backslash Y_3 =$ | | |
| $\backslash Y_4 =$ | | |
| $\backslash Y_5 =$ | | |

Note: Step 19 defined plot 2 to plot residuals (**RESID**) versus string length (**L1**).

28. Press **[ZOOM] 9** to select **9:ZoomStat** from the **ZOOM** menu. The window variables are adjusted automatically, and plot 2 is displayed. This is a scatter plot of the residuals.

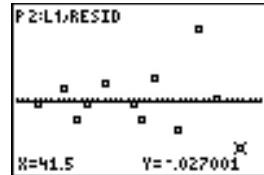


The new residual plot shows that the residuals are random in sign, with the residuals increasing in magnitude as the string length increases.

To see the magnitudes of the residuals, continue with these steps.

29. Press **TRACE**.

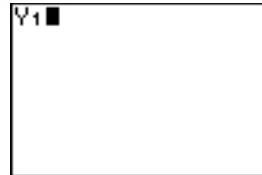
Press **▶** and **◀** to trace the data. Observe the values for **Y** at each point.



With this model, the largest positive residual is about 0.041 and the smallest negative residual is about -0.027. All other residuals are less than 0.02 in magnitude.

Now that you have a good model for the relationship between length and period, you can use the model to predict the period for a given string length. To predict the periods for a pendulum with string lengths of 20 cm and 50 cm, continue with these steps.

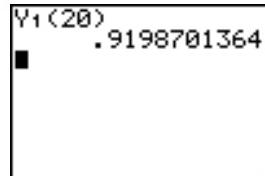
30. Press **VARS** **▶** 1 to display the **VARS Y-VARS FUNCTION** secondary menu, and then press **1** to select **1:Y1**. **Y1** is pasted to the home screen.



31. Press $\boxed{0}$ **20** $\boxed{)}$ to enter a string length of 20 cm.

Press **ENTER** to calculate the predicted time of about 0.92 seconds.

Based on the residual analysis, we would expect the prediction of about 0.92 seconds to be within about 0.02 seconds of the actual value.



32. Press **[2nd] [ENTRY]** to recall the Last Entry.

Press **[\leftarrow] [\leftarrow] [\leftarrow] 5** to change the string length to 50 cm.

33. Press **[ENTER]** to calculate the predicted time of about 1.48 seconds.

Since a string length of 50 cm exceeds the lengths in the data set, and since residuals appear to be increasing as string length increases, we would expect more error with this estimate.

Note: You also can make predictions using the table with the **TABLE SETUP** settings **Indpnt:Ask** and **Depend:Auto** (Chapter 7).

| | |
|-----------|-------------|
| $Y_1(20)$ | ,9198701364 |
| $Y_1(50)$ | 1.484736865 |

Setting Up Statistical Analyses

Using Lists to Store Data

Data for statistical analyses is stored in lists, which you can create and edit using the stat list editor. The TI-83 Plus has six list variables in memory, L₁ through L₆, to which you can store data for statistical calculations. Also, you can store data to list names that you create (Chapter 11).

Setting Up a Statistical Analysis

To set up a statistical analysis, follow these steps. Read the chapter for details.

1. Enter the statistical data into one or more lists.
2. Plot the data.
3. Calculate the statistical variables or fit a model to the data.
4. Graph the regression equation for the plotted data.
5. Graph the residuals list for the given regression model.

Displaying the Stat List Editor

The stat list editor is a table where you can store, edit, and view up to 20 lists that are in memory. Also, you can create list names from the stat list editor.

To display the stat list editor, press **[STAT]**, and then select **1>Edit** from the **STAT EDIT** menu.



| L1 | L2 | L3 | 1 |
|--------|-------|-------|---|
| --- | ----- | ----- | |
| L1(1)= | | | |

The top line displays list names. **L1** through **L6** are stored in columns **1** through **6** after a memory reset. The number of the current column is displayed in the top-right corner.

The bottom line is the entry line. All data entry occurs on this line. The characteristics of this line change according to the current context.

The center area displays up to seven elements of up to three lists; it abbreviates values when necessary. The entry line displays the full value of the current element.

Using the Stat List Editor

Entering a List Name in the Stat List Editor

To enter a list name in the stat list editor, follow these steps.

1. Display the **Name=** prompt in the entry line in either of two ways.
 - Move the cursor onto the list name in the column where you want to insert a list, and then press **[2nd] [INS]**. An unnamed column is displayed and the remaining lists shift right one column.
 - Press **▲** until the cursor is on the top line, and then press **▶** until you reach the unnamed column.

Note: If list names are stored to all 20 columns, you must remove a list name to make room for an unnamed column.

The **Name=** prompt is displayed and alpha-lock is on.

| | L1 | L2 | 1 |
|-----------------------------------|-------|-------|---|
| | ----- | ----- | |
| Name= <input type="text"/> | | | |

2. Enter a valid list name in any of four ways.
- Select a name from the **LIST NAMES** menu (Chapter 11).
 - Enter **L1**, **L2**, **L3**, **L4**, **L5**, or **L6** from the keyboard.
 - Enter an existing user-created list name directly from the keyboard.
 - Enter a new user-created list name.

| | |
|-------|-----|
| Name= | ABC |
|-------|-----|

3. Press **ENTER** or **▼** to store the list name and its elements, if any, in the current column of the stat list editor.

| ABC | L1 | L2 | 1 |
|-------|-------|-------|-------|
| ----- | ----- | ----- | ----- |

ABC =

To begin entering, scrolling, or editing list elements, press **▼**. The rectangular cursor is displayed.

Note: If the list name you entered in step 2 already was stored in another stat list editor column, then the list and its elements, if any, move to the current column from the previous column. Remaining list names shift accordingly.

Creating a Name in the Stat List Editor

To create a name in the stat list editor, follow these steps.

1. Display the **Name=** prompt.
2. Press [*letter from A to Z or θ*] to enter the first letter of the name. The first character cannot be a number.
3. Enter zero to four letters, θ , or numbers to complete the new user-created list name. List names can be one to five characters long.
4. Press **[ENTER]** or **[]** to store the list name in the current column of the stat list editor. The list name becomes an item on the **LIST NAMES** menu (Chapter 11).

Removing a List from the Stat List Editor

To remove a list from the stat list editor, move the cursor onto the list name and then press **[DEL]**. The list is not deleted from memory; it is only removed from the stat list editor.

Note 1: To delete a list name from memory, use the **MEMORY MANAGEMENT/DELETE secondary menu** (Chapter 18).

Note 2: If you archive a list, it will be removed from the stat list editor.

Removing All Lists and Restoring L1 through L6

You can remove all user-created lists from the stat list editor and restore list names **L1** through **L6** to columns **1** through **6** in either of two ways.

- Use **SetUpEditor** with no arguments.
- Reset all memory (Chapter 18).

Clearing All Elements from a List

You can clear all elements from a list in any of five ways.

- Use **ClrList** to clear specified lists.
- In the stat list editor, press **▲** to move the cursor onto a list name, and then press **CLEAR** **ENTER**.
- In the stat list editor, move the cursor onto each element, and then press **DEL** one by one.
- On the home screen or in the program editor, enter **0>dim(*listname*)** to set the dimension of *listname* to 0 (Chapter 11).
- Use **ClrAllLists** to clear all lists in memory (Chapter 18).

Editing a List Element

To edit a list element, follow these steps.

1. Move the rectangular cursor onto the element you want to edit.
2. Press **[ENTER]** to move the cursor to the entry line.

Note: If you want to replace the current value, you can enter a new value without first pressing **[ENTER]**. When you enter the first character, the current value is cleared automatically.

3. Edit the element in the entry line.
 - Press one or more keys to enter the new value. When you enter the first character, the current value is cleared automatically.
 - Press **▶** to move the cursor to the character before which you want to insert, press **[2nd] [INS]**, and then enter one or more characters.
 - Press **▶** to move the cursor to a character you want to delete, and then press **[DEL]** to delete the character.

To cancel any editing and restore the original element at the rectangular cursor, press **[CLEAR] [ENTER]**.

| ABC | L1 | L2 | 1 |
|-------------------------|-------|-------|---|
| 5 | ----- | ----- | |
| 10 | | | |
| 40 | | | |
| 20 | | | |
| 25 | | | |
| ----- | | | |
| $\text{ABC}(3)=25*1000$ | | | |

Note: You can enter expressions and variables for elements.

4. Press **[ENTER]**, **[▲]**, or **[▼]** to update the list. If you entered an expression, it is evaluated. If you entered only a variable, the stored value is displayed as a list element.

| ABC | L1 | L2 | 1 |
|--------------------|-------|-------|---|
| 5 | ----- | ----- | |
| 10 | | | |
| 25000 | | | |
| R0 | | | |
| 20 | | | |
| ----- | | | |
| $\text{ABC}(4)=20$ | | | |

When you edit a list element in the stat list editor, the list is updated in memory immediately.

Attaching Formulas to List Names

Attaching a Formula to a List Name in Stat List Editor

You can attach a formula to a list name in the stat list editor, and then display and edit the calculated list elements. When executed, the attached formula must resolve to a list. Chapter 11 describes in detail the concept of attaching formulas to list names.

To attach a formula to a list name that is stored in the stat list editor, follow these steps.

1. Press **STAT** **ENTER** to display the stat list editor.
2. Press **▲** to move the cursor to the top line.
3. Press **◀** or **▶**, if necessary, to move the cursor onto the list name to which you want to attach the formula.

Note: If a formula in quotation marks is displayed on the entry line, then a formula is already attached to the list name. To edit the formula, press **ENTER**, and then edit the formula.

4. Press **[ALPHA] ["]**, enter the formula, and press **[ALPHA] ["]**.

Note: If you do not use quotation marks, the TI-83 Plus calculates and displays the same initial list of answers, but does not attach the formula for future calculations.

| ABC | L1 | L2 | Z |
|------------------|-------|-------|---|
| 5 | ----- | ----- | |
| 10 | ----- | ----- | |
| 25000 | ----- | ----- | |
| 20 | ----- | ----- | |
| 25 | ----- | ----- | |
| ----- | ----- | ----- | |
| L1 = "LABC+10" ■ | | | |

Note: Any user-created list name referenced in a formula must be preceded by an L symbol (Chapter 11).

5. Press **[ENTER]**. The TI-83 Plus calculates each list element and stores it to the list name to which the formula is attached. A lock symbol is displayed in the stat list editor, next to the list name to which the formula is attached.

lock symbol

| ABC | L1 | L2 | Z |
|----------|-------|-------|---|
| 5 | 15 | ----- | |
| 10 | 20 | ----- | |
| 25000 | 25010 | ----- | |
| 20 | 30 | ----- | |
| 25 | 35 | ----- | |
| ----- | ----- | ----- | |
| L1(0)=15 | | | |

Using the Stat List Editor When Formula-Generated Lists Are Displayed

When you edit an element of a list referenced in an attached formula, the TI-83 Plus updates the corresponding element in the list to which the formula is attached (Chapter 11).

| ABC | L1 | * | L2 | 1 |
|----------|-------|---|-------|---|
| 5 | 15 | | ----- | |
| 10 | 20 | | | |
| 25000 | 25010 | | | |
| 20 | 30 | | | |
| 25 | 35 | | | |
| ----- | ----- | | | |
| ABC(1)=6 | | | | |

| ABC | L1 | * | L2 | 1 |
|-----------|-------|---|-------|---|
| 5 | 16 | | ----- | |
| 10 | 20 | | | |
| 25000 | 25010 | | | |
| 20 | 30 | | | |
| 25 | 35 | | | |
| ----- | ----- | | | |
| ABC(2)=10 | | | | |

When a list with a formula attached is displayed in the stat list editor and you edit or enter elements of another displayed list, then the TI-83 Plus takes slightly longer to accept each edit or entry than when no lists with formulas attached are in view.

Tip: To speed editing time, scroll horizontally until no lists with formulas are displayed, or rearrange the stat list editor so that no lists with formulas are displayed.

Handling Errors Resulting from Attached Formulas

On the home screen, you can attach to a list a formula that references another list with dimension 0 (Chapter 11). However, you cannot display the formula-generated list in the stat list editor or on the home screen until you enter at least one element to the list that the formula references.

All elements of a list referenced by an attached formula must be valid for the attached formula. For example, if **Real** number mode is set and the attached formula is **log(L1)**, then each element of **L1** must be greater than 0, since the logarithm of a negative number returns a complex result.

Tip: If an error menu is returned when you attempt to display a formula-generated list in the stat list editor, you can select **2:Goto**, write down the formula that is attached to the list, and then press **CLEAR** **ENTER** to detach (clear) the formula. You then can use the stat list editor to find the source of the error. After making the appropriate changes, you can reattach the formula to a list.

If you do not want to clear the formula, you can select **1:Quit**, display the referenced list on the home screen, and find and edit the source of the error. To edit an element of a list on the home screen, store the new value to *listname(element#)* (Chapter 11).

Detaching Formulas from List Names

Detaching a Formula from a List Name

You can detach (clear) a formula from a list name in several ways.

For example:

- In the stat list editor, move the cursor onto the name of the list to which a formula is attached. Press [ENTER] [CLEAR] [ENTER]. All list elements remain, but the formula is detached and the lock symbol disappears.
- In the stat list editor, move the cursor onto an element of the list to which a formula is attached. Press [ENTER], edit the element, and then press [ENTER]. The element changes, the formula is detached, and the lock symbol disappears. All other list elements remain.
- Use **ClrList**. All elements of one or more specified lists are cleared, each formula is detached, and each lock symbol disappears. All list names remain.
- Use **ClrAllLists** (Chapter 18). All elements of all lists in memory are cleared, all formulas are detached from all list names, and all lock symbols disappear. All list names remain.

Editing an Element of a Formula-Generated List

As described above, one way to detach a formula from a list name is to edit an element of the list to which the formula is attached. The TI-83 Plus protects against inadvertently detaching the formula from the list name by editing an element of the formula-generated list.

Because of the protection feature, you must press **ENTER** before you can edit an element of a formula-generated list.

The protection feature does not allow you to delete an element of a list to which a formula is attached. To delete an element of a list to which a formula is attached, you must first detach the formula in any of the ways described above.

Switching Stat List Editor Contexts

Stat List Editor Contexts

The stat list editor has four contexts.

- View-elements context
- Edit-elements context
- View-names context
- Enter-name context

The stat list editor is first displayed in view-elements context. To switch through the four contexts, select **1>Edit** from the **STAT EDIT** menu and follow these steps.

| ABC | L1 | L2 | 1 |
|------------------------|-------|-------|---|
| 5 | 15 | ----- | |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |
| ABC = {5, 10, 25000... | | | |

1. Press **▲** to move the cursor onto a list name. You are now in view-names context. Press **▶** and **◀** to view list names stored in other stat list editor columns.

| ABC | L1 | L2 | 1 |
|------------------------|-------|-------|---|
| 5 | 15 | ----- | |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 25 | 30 | | |
| 35 | 35 | | |
| ----- | ----- | | |
| ABC = {5, 10, 25000... | | | |

2. Press **ENTER**. You are now in edit-elements context. You may edit any element in a list. All elements of the current list are displayed in braces ({ }) in the entry line. Press **▶** and **◀** to view more list elements.

| ABC | L1 | L2 | Z |
|-------|-------|----|-------|
| 5 | 15 | | ----- |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |

L1(3)=25000010

3. Press **[ENTER]** again. You are now in view-elements context. Press **[▶]**, **[◀]**, **[▼]**, and **[▲]** to view other list elements. The current element's full value is displayed in the entry line.

| ABC | L1 | L2 | Z |
|-------|-------|----|-------|
| 5 | 15 | | ----- |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |

L1(3)=25000010

4. Press **[ENTER]** again. You are now in edit-elements context. You may edit the current element in the entry line.

| ABC | L1 | L2 | Z |
|-------|-------|----|-------|
| 5 | 15 | | ----- |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |

Name=R

5. Press **[▲]** until the cursor is on a list name, then press **[2nd] [INS]**. You are now in enter-name context.

| ABC | L1 | L2 | Z |
|-------|-------|----|-------|
| 5 | 15 | | ----- |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |

L1 = "LABC+10"

6. Press **[CLEAR]**. You are now in view-names context.

| ABC | L1 | L2 | Z |
|-------|-------|----|-------|
| 5 | 15 | | ----- |
| 10 | 20 | | |
| 2.5E7 | 2.5E7 | | |
| 20 | 30 | | |
| 25 | 35 | | |
| ----- | ----- | | |

L1(1)=15

7. Press **[▼]**. You are now back in view-elements context.

Stat List Editor Contexts

View-Elements Context

In view-elements context, the entry line displays the list name, the current element's place in that list, and the full value of the current element, up to 12 characters at a time. An ellipsis (...) indicates that the element continues beyond 12 characters.

| ABC | L1 | * | L2 | 2 |
|----------------|-------|---|----|---|
| 5 | 15 | | | |
| 10 | 20 | | | |
| 2.5E7 | 2.5E7 | | | |
| 20 | 30 | | | |
| 25 | 35 | | | |
| ----- | ----- | | | |
| L1(3)=25000010 | | | | |

To page down the list six elements, press **ALPHA** ▼. To page up six elements, press **ALPHA** ▲. To delete a list element, press **DEL**. Remaining elements shift up one row. To insert a new element, press **2nd** [INS]. **0** is the default value for a new element.

Edit-Elements Context

In edit-elements context, the data displayed in the entry line depends on the previous context.

- When you switch to edit-elements context from view-elements context, the full value of the current element is displayed. You can edit the value of this element, and then press $\boxed{\downarrow}$ and $\boxed{\uparrow}$ to edit other list elements.



The diagram illustrates the transition between two states of a list element. On the left, in 'view-elements' context, the list element 'ABC' is shown as a table with four columns: L1, L2, L3, and L4. The first row contains values 5, 10, 25000, and 1 respectively. The second row contains 15, 20, 25010, and an ellipsis '-----'. The third row contains 20, 30, 25, and 35. The fourth row contains 35 and another ellipsis '-----'. Below the table, the formula $ABC(3)=25000$ is displayed. An arrow points to the right, indicating the transition to 'edit-elements' context. On the right, the same table structure is shown, but the value '25000' in the L3 column is now highlighted with a black box. Below the table, the formula has changed to $ABC(3)=\boxed{25000}$, where the value '25000' is also enclosed in a black box.

| ABC | L1 | L2 | L3 |
|-----|-------|-------|-------|
| | 5 | 15 | ----- |
| | 10 | 20 | |
| | 25000 | 25010 | |
| | 20 | 30 | |
| | 25 | 35 | |
| | ----- | ----- | ----- |

$ABC(3)=25000$

| ABC | L1 | L2 | L3 |
|-----|-------|-------|-------|
| | 5 | 15 | ----- |
| | 10 | 20 | |
| | 25000 | 25010 | |
| | 20 | 30 | |
| | 25 | 35 | |
| | ----- | ----- | ----- |

$ABC(3)=\boxed{25000}$

- When you switch to edit-elements context from view-names context, the full values of all elements in the list are displayed. An ellipsis indicates that list elements continue beyond the screen. You can press $\boxed{\rightarrow}$ and $\boxed{\leftarrow}$ to edit any element in the list.



The diagram illustrates the transition between two states of a list name. On the left, in 'view-names' context, the list name 'ABC' is shown as a table with four columns: L1, L2, L3, and L4. The first row contains values 5, 10, 25000, and 1 respectively. The second row contains 15, 20, 25010, and an ellipsis '-----'. The third row contains 20, 30, 25, and 35. The fourth row contains 35 and another ellipsis '-----'. Below the table, the formula $ABC = \{5, 10, 25000, \dots\}$ is displayed. An arrow points to the right, indicating the transition to 'edit-elements' context. On the right, the same table structure is shown, but the entire list value '5, 10, 25000, ...' is now highlighted with a black box. Below the table, the formula has changed to $ABC = \boxed{5, 10, 25000\dots}$, where the entire list value is enclosed in a black box.

| ABC | L1 | L2 | L3 |
|-----|-------|-------|-------|
| | 5 | 15 | ----- |
| | 10 | 20 | |
| | 25000 | 25010 | |
| | 20 | 30 | |
| | 25 | 35 | |
| | ----- | ----- | ----- |

$ABC = \{5, 10, 25000, \dots\}$

| ABC | L1 | L2 | L3 |
|-----|-------|-------|-------|
| | 5 | 15 | ----- |
| | 10 | 20 | |
| | 25000 | 25010 | |
| | 20 | 30 | |
| | 25 | 35 | |
| | ----- | ----- | ----- |

$ABC = \boxed{5, 10, 25000\dots}$

Note: In edit-elements context, you can attach a formula to a list name only if you switched to it from view-names context.

View-Names Context

In view-names context, the entry line displays the list name and the list elements.

| NAME | L1 | * | L2 | 1 |
|-------|-------|---|-----------------|---|
| 5 | 15 | | ----- | |
| 10 | 20 | | | |
| 25000 | 25010 | | | |
| 20 | 30 | | | |
| 25 | 35 | | | |
| ----- | ----- | | | |
| ABC | = | (| 5, 10, 25000... |) |

To remove a list from the stat list editor, press **DEL**. Remaining lists shift to the left one column. The list is not deleted from memory.

To insert a name in the current column, press **[2nd] [INS]**. Remaining columns shift to the right one column.

Enter-Name Context

In enter-name context, the **Name=** prompt is displayed in the entry line, and alpha-lock is on.

At the **Name=** prompt, you can create a new list name, paste a list name from L1 to L6 from the keyboard, or paste an existing list name from the **LIST NAMES** menu (Chapter 11). The **L** symbol is not required at the **Name=** prompt.

| | ABC | L1 | * 1 |
|-------|-------|-------|-----|
| | 5 | 15 | |
| | 10 | 20 | |
| | 25000 | 25010 | |
| | 20 | 30 | |
| | 25 | 35 | |
| | ----- | ----- | |
| Name= | | | |

To leave enter-name context without entering a list name, press **CLEAR**.
The stat list editor switches to view-names context.

STAT EDIT Menu

STAT EDIT Menu

To display the **STAT EDIT** menu, press **[STAT]**.

EDIT **CALC TESTS**

- | | |
|---------------|---------------------------------------|
| 1:Edit... | Displays the stat list editor. |
| 2:SortA(| Sorts a list in ascending order. |
| 3:SortD(| Sorts a list in descending order. |
| 4:ClrList | Deletes all elements of a list. |
| 5:SetUpEditor | Stores lists in the stat list editor. |
-

Note: Chapter 13: Inferential Statistics describes the **STAT TESTS** menu items.

SortA(, SortD(

SortA((sort ascending) sorts list elements from low to high values. **SortD(** (sort descending) sorts list elements from high to low values. Complex lists are sorted based on magnitude (modulus). **SortA(** and **SortD(** each can sort in either of two ways.

- With one *listname*, **SortA(** and **SortD(** sort the elements in *listname* and update the list in memory.

- With two or more lists, **SortA(** and **SortD(** sort *keylistname*, and then sort each *dependlist* by placing its elements in the same order as the corresponding elements in *keylistname*. This lets you sort two-variable data on X and keep the data pairs together. All lists must have the same dimension.

The sorted lists are updated in memory.

SortA(*listname*)

SortD(*listname*)

SortA(*keylistname,dependlist1[,dependlist2,...,dependlist n]*)

SortD(*keylistname,dependlist1[,dependlist2,...,dependlist n]*)

| | |
|-------------------------------|-----------------|
| $\{5, 4, 3\} \rightarrow L_3$ | $\{5 \ 4 \ 3\}$ |
| $\{1, 2, 3\} \rightarrow L_4$ | $\{1 \ 2 \ 3\}$ |
| SortA(L_3, L_4) | |
| Done | |

| | |
|-------|-----------------|
| L_3 | $\{3 \ 4 \ 5\}$ |
| L_4 | $\{3 \ 2 \ 1\}$ |
| ■ | |

Note: SortA(and SortD(are the same as SortA(and SortD(on the LIST OPS menu.

ClrList

ClrList clears (deletes) from memory the elements of one or more *listnames*. **ClrList** also detaches any formula attached to a *listname*.

ClrList *listname1,listname2,...,listname n*

Note: To clear from memory all elements of all list names, use **ClrAllLists** (Chapter 18).

SetUpEditor

With **SetUpEditor** you can set up the stat list editor to display one or more *listnames* in the order that you specify. You can specify zero to 20 *listnames*.

Additionally, if you want to use *listnames* which happen to be archived, the SetUp Editor will automatically unarchive the *listnames* and place them in the stat list editor at the same time.

SetUpEditor [*listname1, listname2,..., listname n*]

SetUpEditor with one to 20 *listnames* removes all list names from the stat list editor and then stores *listnames* in the stat list editor columns in the specified order, beginning in column 1.

```
SetUpEditor RESI  
D,L3,L6,TIME,LO  
N,G,A123  
Done
```

| RESID | L3 | L6 | * 1 |
|--------|-------|-------|-----|
| .0013 | 1 | 11 | |
| .00692 | 2 | 12 | |
| .0104 | 3 | 13 | |
| .00115 | 4 | 14 | |
| .0094 | 5 | 15 | |
| .00118 | 6 | 16 | |
| .0106 | ----- | ----- | |

RESID(0) = -.0013125...

| TIME | LONG | A123 | 4 |
|-------|-------|------|---|
| 60 | 56 | 5 | |
| 120 | 82 | 10 | |
| 30 | 74 | 15 | |
| 180 | 55 | 20 | |
| ----- | 36 | 25 | |
| | 98 | 30 | |
| 74 | ----- | | |

TIME(1) = 60

If you enter a *listname* that is not stored in memory already, then *listname* is created and stored in memory; it becomes an item on the **LIST NAMES** menu.

Restoring L1 through L6 to the Stat List Editor

SetUpEditor with no *listnames* removes all list names from the stat list editor and restores list names L1 through L6 in the stat list editor columns 1 through 6.

| SetUpEditor | | | |
|-------------|------|-------|---|
| Done | | | |
| L1 | L2 | L3 | 1 |
| 6.5 | .51 | 1 | |
| 11 | .68 | 2 | |
| 13.2 | .73 | 3 | |
| 15 | .79 | 4 | |
| 18 | .88 | 5 | |
| 23.1 | .99 | 6 | |
| 24.4 | 1.01 | ----- | |
| L1(1)=6.5 | | | |

| L4 | L5 | L6 | * 4 |
|--------|-------|-------|-----|
| ----- | ----- | 11 | |
| | | 12 | |
| | | 13 | |
| | | 14 | |
| | | 15 | |
| | | 16 | |
| | | ----- | |
| L4(1)= | | | |

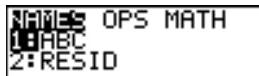
Regression Model Features

Regression Model Features

STAT CALC menu items **3** through **C** are regression models. The automatic residual list and automatic regression equation features apply to all regression models. Diagnostics display mode applies to some regression models.

Automatic Residual List

When you execute a regression model, the automatic residual list feature computes and stores the residuals to the list name **RESID**. **RESID** becomes an item on the **LIST NAMES** menu (Chapter 11).



The TI-83 Plus uses the formula below to compute **RESID** list elements. The next section describes the variable **RegEQ**.

$$\text{RESID} = Y_{\text{listname}} - \text{RegEQ}(X_{\text{listname}})$$

Automatic Regression Equation

Each regression model has an optional argument, *regequ*, for which you can specify a **Y=** variable such as **Y1**. Upon execution, the regression equation is stored automatically to the specified **Y=** variable and the **Y=** function is selected.

```
{1,2,3}→L1:{-1,-  
2,-5}→L2  
{-1 -2 -5}  
LinReg(ax+b) L1,  
L2,Y3■
```

```
LinReg  
y=ax+b  
a=-2  
b=1.3333333333
```

```
Plot1 Plot2 Plot3  
Y1=  
Y2=  
Y3:-2X+1.333333  
3333333
```

Regardless of whether you specify a **Y=** variable for *regequ*, the regression equation always is stored to the TI-83 Plus variable **RegEQ**, which is item 1 on the **VARS Statistics EQ** secondary menu.

```
XY Σ EQ TEST PTS  
1:RegEQ  
2:a  
3:b
```

Note: For the regression equation, you can use the fixed-decimal mode setting to control the number of digits stored after the decimal point (Chapter 1). However, limiting the number of digits to a small number could affect the accuracy of the fit.

Diagnostics Display Mode

When you execute some regression models, the TI-83 Plus computes and stores diagnostics values for r (correlation coefficient) and r^2 (coefficient of determination) or for R^2 (coefficient of determination).

r and r^2 are computed and stored for these regression models.

LinReg(ax+b)

LnReg

PwrReg

LinReg(a+bx)

ExpReg

R^2 is computed and stored for these regression models.

QuadReg

CubicReg

QuartReg

The r and r^2 that are computed for **LnReg**, **ExpReg**, and **PwrReg** are based on the linearly transformed data. For example, for **ExpReg** ($y=ab^x$), r and r^2 are computed on $\ln y = \ln a + x(\ln b)$.

By default, these values are not displayed with the results of a regression model when you execute it. However, you can set the diagnostics display mode by executing the **DiagnosticOn** or **DiagnosticOff** instruction. Each instruction is in the **CATALOG** (Chapter 15).



Note: To set **DiagnosticOn** or **DiagnosticOff** from the home screen, press **[2nd]** [CATALOG], and then select the instruction for the mode you want. The instruction is pasted to the home screen. Press **[ENTER]** to set the mode.

When **DiagnosticOn** is set, diagnostics are displayed with the results when you execute a regression model.

```
DiagnosticOn
Done
LinReg(ax+b) L1,
L2■
```

```
LinReg
y=ax+b
a=-2
b=1.333333333
r2=.9230769231
r=-.9607689228
```

When **DiagnosticOff** is set, diagnostics are not displayed with the results when you execute a regression model.

```
DiagnosticOff
Done
LinReg(ax+b) L1,
L2■
```

```
LinReg
y=ax+b
a=-2
b=1.333333333
```

STAT CALC Menu

STAT CALC Menu

To display the STAT CALC menu, press **STAT** **►**.

EDIT **CALC** TESTS

- | | |
|----------------|------------------------------------|
| 1:1-Var Stats | Calculates 1-variable statistics. |
| 2:2-Var Stats | Calculates 2-variable statistics. |
| 3:Med-Med | Calculates a median-median line. |
| 4:LinReg(ax+b) | Fits a linear model to data. |
| 5:QuadReg | Fits a quadratic model to data. |
| 6:CubicReg | Fits a cubic model to data. |
| 7:QuartReg | Fits a quartic model to data. |
| 8:LinReg(a+bx) | Fits a linear model to data. |
| 9:LnReg | Fits a logarithmic model to data. |
| 0:ExpReg | Fits an exponential model to data. |
| A:PwrReg | Fits a power model to data. |
| B:Logistic | Fits a logistic model to data. |
| C:SinReg | Fits a sinusoidal model to data. |
-

For each STAT CALC menu item, if neither *Xlistname* nor *Ylistname* is specified, then the default list names are **L1** and **L2**. If you do not specify *freqlist*, then the default is 1 occurrence of each list element.

Frequency of Occurrence for Data Points

For most **STAT CALC** menu items, you can specify a list of data occurrences, or frequencies (*freqlist*).

Each element in *freqlist* indicates how many times the corresponding data point or data pair occurs in the data set you are analyzing.

For example, if $L1=\{15,12,9,14\}$ and $\text{LFREQ}=\{1,4,1,3\}$, then the TI-83 Plus interprets the instruction **1-Var Stats L1, LFREQ** to mean that 15 occurs once, 12 occurs four times, 9 occurs once, and 14 occurs three times.

Each element in *freqlist* must be ≥ 0 , and at least one element must be > 0 .

Noninteger *freqlist* elements are valid. This is useful when entering frequencies expressed as percentages or parts that add up to 1.

However, if *freqlist* contains noninteger frequencies, **Sx** and **Sy** are undefined; values are not displayed for **Sx** and **Sy** in the statistical results.

1-Var Stats

1-Var Stats (one-variable statistics) analyzes data with one measured variable. Each element in *freqlist* is the frequency of occurrence for each corresponding data point in *Xlistname*. *freqlist* elements must be real numbers > 0 .

1-Var Stats [*Xlistname,freqlist*]

```
1-Var Stats L1,L  
2■
```

2-Var Stats

2-Var Stats (two-variable statistics) analyzes paired data. *Xlistname* is the independent variable. *Ylistname* is the dependent variable. Each element in *freqlist* is the frequency of occurrence for each data pair (*Xlistname*, *Ylistname*).

2-Var Stats [*Xlistname,Ylistname,freqlist*]

Med-Med (ax+b)

Med-Med (median-median) fits the model equation $y=ax+b$ to the data using the median-median line (resistant line) technique, calculating the summary points x_1 , y_1 , x_2 , y_2 , x_3 , and y_3 . **Med-Med** displays values for **a** (slope) and **b** (y-intercept).

Med-Med [*Xlistname,Ylistname,freqlist,regequ*]

```
Med-Med L3,L4,Y2  
■
```

```
Med-Med  
y=ax+b  
a=.875  
b=1.541666667
```

LinReg (ax+b)

LinReg(ax+b) (linear regression) fits the model equation $y=ax+b$ to the data using a least-squares fit. It displays values for **a** (slope) and **b** (y-intercept); when **DiagnosticOn** is set, it also displays values for R^2 and **r**.

LinReg(ax+b) [*Xlistname, Ylistname, freqlist, regequ*]

QuadReg (ax²+bx+c)

QuadReg (quadratic regression) fits the second-degree polynomial $y=ax^2+bx+c$ to the data. It displays values for **a**, **b**, and **c**; when **DiagnosticOn** is set, it also displays a value for **R²**. For three data points, the equation is a polynomial fit; for four or more, it is a polynomial regression. At least three data points are required.

QuadReg [*Xlistname, Ylistname, freqlist, regequ*]

CubicReg—(ax³+bx²+cx+d)

CubicReg (cubic regression) fits the third-degree polynomial $y=ax^3+bx^2+cx+d$ to the data. It displays values for **a**, **b**, **c**, and **d**; when **DiagnosticOn** is set, it also displays a value for **R²**. For four points, the equation is a polynomial fit; for five or more, it is a polynomial regression. At least four points are required.

CubicReg [*Xlistname, Ylistname, freqlist, regequ*]

QuartReg—(ax⁴+bx³+cx²+ dx+e)

QuartReg (quartic regression) fits the fourth-degree polynomial $y=ax^4+bx^3+cx^2+dx+e$ to the data. It displays values for **a**, **b**, **c**, **d**, and **e**; when **DiagnosticOn** is set, it also displays a value for **R²**. For five points, the equation is a polynomial fit; for six or more, it is a polynomial regression. At least five points are required.

QuartReg [*Xlistname, Ylistname, freqlist, regequ*]

LinReg—(a+bx)

LinReg(a+bx) (linear regression) fits the model equation $y=a+bx$ to the data using a least-squares fit. It displays values for **a** (y-intercept) and **b** (slope); when **DiagnosticOn** is set, it also displays values for **r²** and **r**.

LinReg(a+bx) [*Xlistname, Ylistname, freqlist, regequ*]

LnReg—(a+b ln(x))

LnReg (logarithmic regression) fits the model equation $y=a+b \ln(x)$ to the data using a least-squares fit and transformed values $\ln(x)$ and y . It displays values for **a** and **b**; when **DiagnosticOn** is set, it also displays values for **r²** and **r**.

LnReg [*Xlistname,Ylistname,freqlist,regequ*]

ExpReg—(ab^x)

ExpReg (exponential regression) fits the model equation $y=ab^x$ to the data using a least-squares fit and transformed values x and $\ln(y)$. It displays values for **a** and **b**; when **DiagnosticOn** is set, it also displays values for **r²** and **r**.

ExpReg [*Xlistname,Ylistname,freqlist,regequ*]

PwrReg—(ax^b)

PwrReg (power regression) fits the model equation $y=ax^b$ to the data using a least-squares fit and transformed values $\ln(x)$ and $\ln(y)$. It displays values for **a** and **b**; when **DiagnosticOn** is set, it also displays values for **r²** and **r**.

PwrReg [*Xlistname,Ylistname,freqlist,regequ*]

Logistic— $c/(1+a*e^{-bx})$

Logistic fits the model equation $y=c/(1+a*e^{-bx})$ to the data using an iterative least-squares fit. It displays values for **a**, **b**, and **c**.

Logistic [*Xlistname,Ylistname,freqlist,regequ*]

SinReg—a $\sin(bx+c)+d$

SinReg (sinusoidal regression) fits the model equation $y=a \sin(bx+c)+d$ to the data using an iterative least-squares fit. It displays values for **a**, **b**, **c**, and **d**. At least four data points are required. At least two data points per cycle are required in order to avoid aliased frequency estimates.

SinReg [*iterations*,*Xlistname*,*Ylistname*,*period*,*regequ*]

iterations is the maximum number of times the algorithm will iterate to find a solution. The value for *iterations* can be an integer ≥ 1 and ≤ 16 ; if not specified, the default is 3. The algorithm may find a solution before *iterations* is reached. Typically, larger values for *iterations* result in longer execution times and better accuracy for **SinReg**, and vice versa.

A *period* guess is optional. If you do not specify *period*, the difference between time values in *Xlistname* must be equal and the time values must be ordered in ascending sequential order. If you specify *period*, the algorithm may find a solution more quickly, or it may find a solution when it would not have found one if you had omitted a value for *period*. If you specify *period*, the differences between time values in *Xlistname* can be unequal.

Note: The output of **SinReg** is always in radians, regardless of the Radian/Degree mode setting.

SinReg Example: Daylight Hours in Alaska for One Year

Compute the regression model for the number of hours of daylight in Alaska during one year.

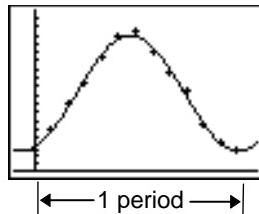
```
seq(X,X,1,361,30  
)  
→ L1: {5.5,8,11,1  
3.5,16.5,19,19.5  
,17,14.5,12.5,8.  
5,6,5,5.5} → L2  
{5.5 8 11 13.5 ...  
■
```

→

| |
|---|
| Plot1 Plot2 Plot3 |
| On Off |
| Type: <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| Xlist:L1 |
| Vlist:L2 |
| Mark: <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> |

```
SinReg L1,L2,Y1■
```

```
SinReg  
y=a*sin(bx+c)+d  
a=6.770292445  
b=.0162697853  
c=-1.215498579  
d=12.18138372  
■
```



With noisy data, you will achieve better convergence results when you specify an accurate estimate for *period*. You can obtain a *period* guess in either of two ways.

- Plot the data and trace to determine the x-distance between the beginning and end of one complete period, or cycle. The illustration above and to the right graphically depicts a complete period, or cycle.

- Plot the data and trace to determine the x-distance between the beginning and end of N complete periods, or cycles. Then divide the total distance by N.

After your first attempt to use **SinReg** and the default value for *iterations* to fit the data, you may find the fit to be approximately correct, but not optimal. For an optimal fit, execute **SinReg 16,Xlistname,Ylistname,2π / b** where *b* is the value obtained from the previous **SinReg** execution.

Statistical Variables

The statistical variables are calculated and stored as indicated below. To access these variables for use in expressions, press **VARS**, and select **5:Statistics**. Then select the **VARS** menu shown in the column below under **VARS** menu. If you edit a list or change the type of analysis, all statistical variables are cleared.

| Variables | 1-Var Stats | 2-Var Stats | Other | VARS menu |
|------------------------------------|--------------|--------------|-------|-----------|
| mean of x values | \bar{x} | \bar{x} | | XY |
| sum of x values | Σx | Σx | | Σ |
| sum of x^2 values | Σx^2 | Σx^2 | | Σ |
| sample standard deviation of x | S_x | S_x | | XY |
| population standard deviation of x | σ_x | σ_x | | XY |
| number of data points | n | n | | XY |
| mean of y values | | \bar{y} | | XY |
| sum of y values | | Σy | | Σ |
| sum of y^2 values | | Σy^2 | | Σ |
| sample standard deviation of y | | S_y | | XY |
| population standard deviation of y | | σ_y | | XY |
| sum of $x * y$ | | Σxy | | Σ |
| minimum of x values | | $\min X$ | | XY |

| Variables | 1-Var Stats | 2-Var Stats | Other | VARS menu |
|---|----------------|----------------|---|--------------|
| maximum of x values | maxX | maxX | | XY |
| minimum of y values | | minY | | XY |
| maximum of y values | | maxY | | XY |
| 1st quartile | Q1 | | | PTS |
| median | Med | | | PTS |
| 3rd quartile | Q3 | | | PTS |
| regression/fit coefficients | | | a, b | EQ |
| polynomial, Logistic , and SinReg coefficients | | | a, b, c, d, e | EQ |
| correlation coefficient | | | r | EQ |
| coefficient of determination | | | r², R² | EQ |
| regression equation | | | RegEQ | EQ |
| summary points (Med-Med only) | | | x₁, y₁, x₂, y₂, x₃, y₃ | PTS |

Q₁ and Q₃

The first quartile (**Q₁**) is the median of points between **minX** and **Med** (median). The third quartile (**Q₃**) is the median of points between **Med** and **maxX**.

Statistical Analysis in a Program

Entering Stat Data

You can enter statistical data, calculate statistical results, and fit models to data from a program. You can enter statistical data into lists directly within the program (Chapter 11).

```
PROGRAM:STATS  
:(1,2,3)→L1  
:(-1,-2,-5)→L2
```

Statistical Calculations

To perform a statistical calculation from a program, follow these steps.

1. On a blank line in the program editor, select the type of calculation from the **STAT CALC** menu.
2. Enter the names of the lists to use in the calculation. Separate the list names with a comma.
3. Enter a comma and then the name of a **Y=** variable, if you want to store the regression equation to a **Y=** variable.

```
PROGRAM:STATS  
:(1,2,3)→L1  
:(-1,-2,-5)→L2  
:LinReg(ax+b) L1,  
L2,Y2  
:
```

Statistical Plotting

Steps for Plotting Statistical Data in Lists

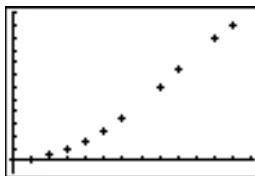
You can plot statistical data that is stored in lists. The six types of plots available are scatter plot, xyLine, histogram, modified box plot, regular box plot, and normal probability plot. You can define up to three plots.

To plot statistical data in lists, follow these steps.

1. Store the stat data in one or more lists.
2. Select or deselect $Y=$ functions as appropriate.
3. Define the stat plot.
4. Turn on the plots you want to display.
5. Define the viewing window.
6. Display and explore the graph.

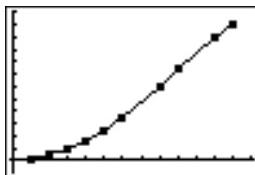
(**Scatter**)

Scatter plots plot the data points from **Xlist** and **Ylist** as coordinate pairs, showing each point as a box (\square), cross ($+$), or dot (\cdot). **Xlist** and **Ylist** must be the same length. You can use the same list for **Xlist** and **Ylist**.



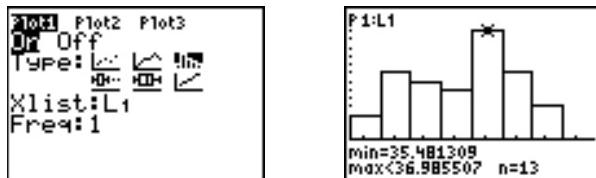
(**xyLine**)

xyLine is a scatter plot in which the data points are plotted and connected in order of appearance in **Xlist** and **Ylist**. You may want to use [SortA\(](#) or [SortD\(](#) to sort the lists before you plot them.



(Histogram)

Histogram plots one-variable data. The **Xscl** window variable value determines the width of each bar, beginning at **Xmin**. **ZoomStat** adjusts **Xmin**, **Xmax**, **Ymin**, and **Ymax** to include all values, and also adjusts **Xscl**. The inequality $(\text{Xmax} - \text{Xmin}) / \text{Xscl} \leq 47$ must be true. A value that occurs on the edge of a bar is counted in the bar to the right.

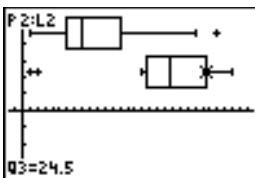


(ModBoxplot)

ModBoxplot (modified box plot) plots one-variable data, like the regular box plot, except points that are $1.5 * \text{Interquartile Range}$ beyond the quartiles. (The Interquartile Range is defined as the difference between the third quartile **Q3** and the first quartile **Q1**.) These points are plotted individually beyond the whisker, using the **Mark** (\square or $+$ or \bullet) you select. You can trace these points, which are called outliers.

The prompt for outlier points is **x=**, except when the outlier is the maximum point (**maxX**) or the minimum point (**minX**). When outliers exist, the end of each whisker will display **x=**. When no outliers exist, **minX** and **maxX** are the prompts for the end of each whisker. **Q1**, **Med** (median), and **Q3** define the box.

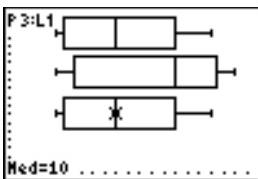
Box plots are plotted with respect to **Xmin** and **Xmax**, but ignore **Ymin** and **Ymax**. When two box plots are plotted, the first one plots at the top of the screen and the second plots in the middle. When three are plotted, the first one plots at the top, the second in the middle, and the third at the bottom.



(Boxplot)

Boxplot (regular box plot) plots one-variable data. The whiskers on the plot extend from the minimum data point in the set (**minX**) to the first quartile (**Q1**) and from the third quartile (**Q3**) to the maximum point (**maxX**). The box is defined by **Q1**, **Med** (median), and **Q3**.

Box plots are plotted with respect to **Xmin** and **Xmax**, but ignore **Ymin** and **Ymax**. When two box plots are plotted, the first one plots at the top of the screen and the second plots in the middle. When three are plotted, the first one plots at the top, the second in the middle, and the third at the bottom.



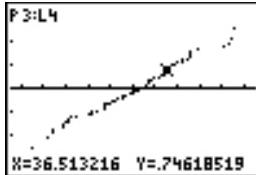
↙ (NormProbPlot)

NormProbPlot (normal probability plot) plots each observation **X** in **Data List** versus the corresponding quantile **z** of the standard normal distribution. If the plotted points lie close to a straight line, then the plot indicates that the data are normal.

Enter a valid list name in the **Data List** field. Select **X** or **Y** for the **Data Axis** setting.

- If you select **X**, the TI-83 Plus plots the data on the x-axis and the z-values on the y-axis.
- If you select **Y**, the TI-83 Plus plots the data on the y-axis and the z-values on the x-axis.

```
randNorm(35,2,90  
)→L4  
(35.11436075 36...
```



Defining the Plots

To define a plot, follow these steps.

1. Press **[2nd]** [STAT PLOT]. The **STAT PLOTS** menu is displayed with the current plot definitions.



2. Select the plot you want to use. The stat plot editor is displayed for the plot you selected.



- Press **[ENTER]** to select **On** if you want to plot the statistical data immediately. The definition is stored whether you select **On** or **Off**.
- Select the type of plot. Each type prompts for the options checked in this table.

| Plot Type | XList | YList | Mark | Freq | Data List | Data Axis |
|-----------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

- Enter list names or select options for the plot type.
 - Xlist** (list name containing independent data)
 - Ylist** (list name containing dependent data)
 - Mark** (or **+** or **•**)

- **Freq** (frequency list for **Xlist** elements; default is **1**)
- **Data List** (list name for **NormProbPlot**)
- **Data Axis** (axis on which to plot **Data List**)

Displaying Other Stat Plot Editors

Each stat plot has a unique stat plot editor. The name of the current stat plot (**Plot1**, **Plot2**, or **Plot3**) is highlighted in the top line of the stat plot editor. To display the stat plot editor for a different plot, press **◀**, **▶**, and **█** to move the cursor onto the name in the top line, and then press **ENTER**. The stat plot editor for the selected plot is displayed, and the selected name remains highlighted.



Turning On and Turning Off Stat Plots

PlotsOn and **PlotsOff** allow you to turn on or turn off stat plots from the home screen or a program. With no plot number, **PlotsOn** turns on all plots and **PlotsOff** turns off all plots. With one or more plot numbers (1, 2, and 3), **PlotsOn** turns on specified plots, and **PlotsOff** turns off specified plots.

PlotsOff [1,2,3]

PlotsOn [1,2,3]

PlotsOff Done
PlotsOn 3 Done
■

STAT PLOTS
1:Plot1...Off
 └─ L1 1 □
2:Plot2...Off
 └─ L1 RESID □
3:Plot3...On
 └─ L4 xaxis .
4:PlotsOff

Note: You also can turn on and turn off stat plots in the top line of the Y= editor (Chapter 3).

Defining the Viewing Window

Stat plots are displayed on the current graph. To define the viewing window, press **WINDOW** and enter values for the window variables.

ZoomStat redefines the viewing window to display all statistical data points.

Tracing a Stat Plot

When you trace a scatter plot or **xyLine**, tracing begins at the first element in the lists.

When you trace a histogram, the cursor moves from the top center of one column to the top center of the next, starting at the first column.

When you trace a box plot, tracing begins at **Med** (the median). Press **◀** to trace to **Q1** and **minX**. Press **▶** to trace to **Q3** and **maxX**.

When you press **▲** or **▼** to move to another plot or to another **Y=** function, tracing moves to the current or beginning point on that plot (not the nearest pixel).

The **ExprOn/ExprOff** format setting applies to stat plots (Chapter 3). When **ExprOn** is selected, the plot number and plotted data lists are displayed in the top-left corner.

Statistical Plotting in a Program

Defining a Stat Plot in a Program

To display a stat plot from a program, define the plot, and then display the graph.

To define a stat plot from a program, begin on a blank line in the program editor and enter data into one or more lists; then, follow these steps.

1. Press **[2nd] [STAT PLOT]** to display the **STAT PLOTS** menu.



2. Select the plot to define, which pastes **Plot1()**, **Plot2()**, or **Plot3()** to the cursor location.



3. Press **2nd** [STAT PLOT] **▶** to display the **STAT TYPE** menu.

PLOTS TYPE MARK
1:Scatter
2:xyLine
3:Histogram
4:ModBoxPlot
5:BoxPlot
6:NormProbPlot

4. Select the type of plot, which pastes the name of the plot type to the cursor location.

PROGRAM:PLOT
:(1,2,3,4)→L₁
:(5,6,7,8)→L₂
:Plot2(Scatter■

5. Press **[**. Enter the list names, separated by commas.

6. Press **[**, **2nd** [STAT PLOT] **◀** to display the **STAT PLOT MARK** menu. (This step is not necessary if you selected **3:Histogram** or **5:Boxplot** in step 4.)

PLOTS TYPE MARK
1:
2:+
3:

Select the type of mark (**□** or **+** or **•**) for each data point. The selected mark symbol is pasted to the cursor location.

7. Press  **ENTER** to complete the command line.

```
PROGRAM:PLOT
:(1,2,3,4)→L1
:(5,6,7,8)→L2
:Plot2(Scatter,L1,L2,“”)
:■
```

Displaying a Stat Plot from a Program

To display a plot from a program, use the **DispGraph** instruction (Chapter 16) or any of the **zoom** instructions (Chapter 3).

```
PROGRAM:PLOT
:(1,2,3,4)→L1
:(5,6,7,8)→L2
:Plot2(Scatter,L1,L2,“”)
:DispGraph
:■
```

```
PROGRAM:PLOT
:(1,2,3,4)→L1
:(5,6,7,8)→L2
:Plot2(Scatter,L1,L2,“”)
:ZoomStat
:■
```

Chapter 13: **Inferential Statistics and Distributions**

Getting Started: Mean Height of a Population

Getting Started is a fast-paced introduction. Read the chapter for details.

Suppose you want to estimate the mean height of a population of women given the random sample below. Because heights among a biological population tend to be normally distributed, a *t* distribution confidence interval can be used when estimating the mean. The 10 height values below are the first 10 of 90 values, randomly generated from a normally distributed population with an assumed mean of 165.1 centimeters and a standard deviation of 6.35 centimeters (`randNorm(165.1,6.35,90)` with a seed of 789).

Height (in centimeters) of Each of 10 Women

169.43 168.33 159.55 169.97 159.79 181.42 171.17 162.04
167.15 159.53

1. Press **STAT** **ENTER** to display the stat list editor.

Press **▲** to move the cursor onto **L1**, and then press **2nd** **[INS]**. The **Name=** prompt is displayed on the bottom line. The **A** cursor indicates that alpha-lock is on. The existing list name columns shift to the right.

| | L1 | L2 | 1 |
|---------------|-------|-------|---|
| | ----- | ----- | |
| Name=A | | | |

Note: Your stat editor may not look like the one pictured here, depending on the lists you have already stored.

2. Enter **[H] [G] [H] [T]** at the **Name=** prompt, and then press **ENTER**. The list to which you will store the women's height data is created.

Press **▼** to move the cursor onto the first row of the list. **HGHT(1)=** is displayed on the bottom line.

| HGHT | L1 | L2 | 1 |
|-----------------|-------|-------|---|
| | ----- | ----- | |
| HGHT(1)= | | | |

3. Press **169 □ 43** to enter the first height value. As you enter it, it is displayed on the bottom line.

Press **ENTER**. The value is displayed in the first row, and the rectangular cursor moves to the next row.

| HGHT | L1 | L2 | 3 |
|------------------|----|----|---|
| 159.79 | | | |
| 161.42 | | | |
| 171.17 | | | |
| 162.04 | | | |
| 167.15 | | | |
| 159.53 | | | |
| HGHT(11)= | | | |

Enter the other nine height values the same way.

- Press **STAT** **▼** to display the **STAT TESTS** menu, and then press **▼** until **8:TInterval** is highlighted.



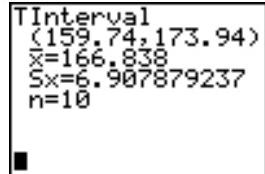
- Press **ENTER** to select **8:TInterval**. The inferential stat editor for **TInterval** is displayed. If **Data** is not selected for **Inpt:**, press **◀** **ENTER** to select **Data**.

Press **▼** and **[H] [G] [H] [T]** at the **List:** prompt (alpha-lock is on).



Press **▼** **▼** **▼** **99** to enter a 99 percent confidence level at the **C-Level:** prompt.

- Press **▼** to move the cursor onto **Calculate**, and then press **ENTER**. The confidence interval is calculated, and the **TInterval** results are displayed on the home screen.



Interpret the results.

The first line, **(159.74,173.94)**, shows that the 99 percent confidence interval for the population mean is between about 159.74 centimeters and 173.94 centimeters. This is about a 14.2 centimeters spread.

The .99 confidence level indicates that in a very large number of samples, we expect 99 percent of the intervals calculated to contain the population mean. The actual mean of the population sampled is 165.1 centimeters, which is in the calculated interval.

The second line gives the mean height of the sample \bar{x} used to compute this interval. The third line gives the sample standard deviation **Sx**. The bottom line gives the sample size **n**.

To obtain a more precise bound on the population mean μ of women's heights, increase the sample size to 90. Use a sample mean \bar{x} of 163.8 and sample standard deviation **Sx** of 7.1 calculated from the larger random sample. This time, use the **Stats** (summary statistics) input option.

7. Press **STAT** **►** **8** to display the inferential stat editor for **TInterval**.

Press **►** **[ENTER]** to select **Inpt:Stats**. The editor changes so that you can enter summary statistics as input.

```
TInterval
Inpt:Data Stats
x:166.838
Sx:6.907879237...
n:10
C-Level:.99
Calculate
```

8. Press $\boxed{\square}$ **163** $\boxed{.}$ **8** **[ENTER]** to store 163.8 to \bar{x} .

Press **7** $\boxed{.}$ **1** **[ENTER]** to store 7.1 to S_x .

Press **90** **[ENTER]** to store 90 to n .

```
TInterval  
Inpt:Data STATS  
x:163.8  
Sx:7.1  
n:90  
C-Level:.99  
Calculate
```

9. Press $\boxed{\square}$ to move the cursor onto **Calculate**, and then press **[ENTER]** to calculate the new 99 percent confidence interval. The results are displayed on the home screen.

```
TInterval  
(161.83, 165.77)  
x=163.8  
Sx=7.1  
n=90
```

If the height distribution among a population of women is normally distributed with a mean μ of 165.1 centimeters and a standard deviation σ of 6.35 centimeters, what height is exceeded by only 5 percent of the women (the 95th percentile)?

10. Press **CLEAR** to clear the home screen.

Press **2nd** **[DISTR]** to display the **DISTR** (distributions) menu.

```
DISTR DRAW  
1:normalpdf()  
2:normalcdf()  
3:invNorm()  
4:tpdf()  
5:tcdf()  
6:x2pdf()  
7:x2cdf()
```

11. Press 3 to paste `invNorm(` to the home screen.

Press $\boxed{3}$ $\boxed{.95}$ $\boxed{,}$ $\boxed{165}$ $\boxed{.}$ $\boxed{1}$ $\boxed{,}$ $\boxed{6}$ $\boxed{.}$ $\boxed{35}$ $\boxed{)}$ $\boxed{\text{ENTER}}$.

.95 is the area, 165.1 is μ , and 6.35 is σ .

```
invNorm(.95,165.  
1,6.35)  
175.5448205
```

The result is displayed on the home screen; it shows that five percent of the women are taller than 175.5 centimeters.

Now graph and shade the top 5 percent of the population.

12. Press `WINDOW` and set the window variables to these values.

| | | |
|----------|-----------|--------|
| Xmin=145 | Ymin=-.02 | Xres=1 |
| Xmax=185 | Ymax=.08 | |
| Xscl=5 | Yscl=0 | |

```
WINDOW  
Xmin=145  
Xmax=185  
Xscl=5  
Ymin=-.02  
Ymax=.08  
Yscl=0  
Xres=1
```

13. Press `2nd [DISTR] \blacktriangleright` to display the `DISTR DRAW` menu.

```
DISTR  $\blacktriangleright$   
1:ShadeNorm()  
2:Shade_t()  
3:ShadeX $\Sigma$ ()  
4:ShadeF()
```

14. Press **[ENTER]** to paste **ShadeNorm**(to the home screen.

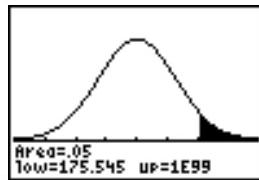
Press **2nd [ANS] , 1 2nd [EE] 99 , 165 . 1 , 6 . 35)**.

```
invNorm(.95,165.  
1,6.35)  
175.5448205  
ShadeNorm(Ans,1E  
99,165.1,6.35)■
```

Ans (175.5448205 from step 11) is the lower bound. **1E99** is the upper bound. The normal curve is defined by a mean μ of 165.1 and a standard deviation σ of 6.35.

15. Press **[ENTER]** to plot and shade the normal curve.

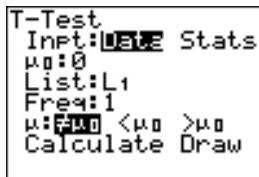
Area is the area above the 95th percentile. **low** is the lower bound. **up** is the upper bound.



Inferential Stat Editors

Displaying the Inferential Stat Editors

When you select a hypothesis test or confidence interval instruction from the home screen, the appropriate inferential statistics editor is displayed. The editors vary according to each test or interval's input requirements. Below is the inferential stat editor for **T-Test**.



Note: When you select the **ANOVA(** instruction, it is pasted to the home screen. **ANOVA(** does not have an editor screen.

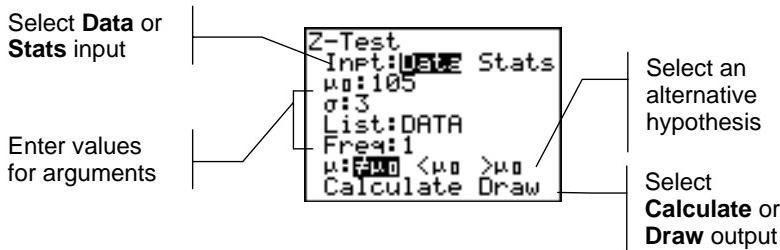
Using an Inferential Stat Editor

To use an inferential stat editor, follow these steps.

1. Select a hypothesis test or confidence interval from the **STAT TESTS** menu. The appropriate editor is displayed.
2. Select **Data** or **Stats** input, if the selection is available. The appropriate editor is displayed.

3. Enter real numbers, list names, or expressions for each argument in the editor.
4. Select the alternative hypothesis (\neq , $<$, or $>$) against which to test, if the selection is available.
5. Select **No** or **Yes** for the **Pooled** option, if the selection is available.
6. Select **Calculate** or **Draw** (when **Draw** is available) to execute the instruction.
 - When you select **Calculate**, the results are displayed on the home screen.
 - When you select **Draw**, the results are displayed in a graph.

This chapter describes the selections in the above steps for each hypothesis test and confidence interval instruction.



Selecting Data or Stats

Most inferential stat editors prompt you to select one of two types of input. (**1-PropZInt** and **2-PropZTest**, **1-PropZInt** and **2-PropZInt**, χ^2 -**Test**, and **LinRegTTest** do not.)

- Select **Data** to enter the data lists as input.
- Select **Stats** to enter summary statistics, such as \bar{x} , **Sx**, and **n**, as input.

To select **Data** or **Stats**, move the cursor to either **Data** or **Stats**, and then press **[ENTER]**.

Entering the Values for Arguments

Inferential stat editors require a value for every argument. If you do not know what a particular argument symbol represents, see the [Inferential Statistics Input Descriptions tables](#).

When you enter values in any inferential stat editor, the TI-83 Plus stores them in memory so that you can run many tests or intervals without having to reenter every value.

Selecting an Alternative Hypothesis ($\neq < >$)

Most of the inferential stat editors for the hypothesis tests prompt you to select one of three alternative hypotheses.

- The first is a \neq alternative hypothesis, such as $\mu \neq \mu_0$ for the **Z-Test**.
- The second is a $<$ alternative hypothesis, such as $\mu_1 < \mu_2$ for the **2-SampTTest**.
- The third is a $>$ alternative hypothesis, such as $p_1 > p_2$ for the **2-PropZTest**.

To select an alternative hypothesis, move the cursor to the appropriate alternative, and then press **[ENTER]**.

Selecting the Pooled Option

Pooled (2-SampTTest and 2-SampTInt only) specifies whether the variances are to be pooled for the calculation.

- Select **No** if you do not want the variances pooled. Population variances can be unequal.
- Select **Yes** if you want the variances pooled. Population variances are assumed to be equal.

To select the **Pooled** option, move the cursor to **Yes**, and then press **[ENTER]**.

Selecting Calculate or Draw for a Hypothesis Test

After you have entered all arguments in an inferential stat editor for a hypothesis test, you must select whether you want to see the calculated results on the home screen (**Calculate**) or on the graph screen (**Draw**).

- **Calculate** calculates the test results and displays the outputs on the home screen.
- **Draw** draws a graph of the test results and displays the test statistic and p-value with the graph. The window variables are adjusted automatically to fit the graph.

To select **Calculate** or **Draw**, move the cursor to either **Calculate** or **Draw**, and then press **ENTER**. The instruction is immediately executed.

Selecting Calculate for a Confidence Interval

After you have entered all arguments in an inferential stat editor for a confidence interval, select **Calculate** to display the results. The **Draw** option is not available.

When you press **ENTER**, **Calculate** calculates the confidence interval results and displays the outputs on the home screen.

Bypassing the Inferential Stat Editors

To paste a hypothesis test or confidence interval instruction to the home screen without displaying the corresponding inferential stat editor, select the instruction you want from the **CATALOG** menu. Appendix A describes the input syntax for each hypothesis test and confidence interval instruction.

```
2-SampZTest<
```

Note: You can paste a hypothesis test or confidence interval instruction to a command line in a program. From within the program editor, select the instruction from either the **CATALOG** (Chapter 15) or the **STAT TESTS** menu.

STAT TESTS Menu

STAT TESTS Menu

To display the **STAT TESTS** menu, press **STAT** **1**. When you select an inferential statistics instruction, the appropriate inferential stat editor is displayed.

Most **STAT TESTS** instructions store some output variables to memory. For a list of these variables, see the Test and Interval Output Variables table.

| EDIT | CALC | TESTS |
|------|-------------------|---|
| 1: | Z-Test... | Test for 1 μ , known σ |
| 2: | T-Test... | Test for 1 μ , unknown σ |
| 3: | 2-SampZTest... | Test comparing 2 μ 's, known σ 's |
| 4: | 2-SampTTest... | Test comparing 2 μ 's, unknown σ 's |
| 5: | 1-PropZTest... | Test for 1 proportion |
| 6: | 2-PropZTest... | Test comparing 2 proportions |
| 7: | ZInterval... | Confidence interval for 1 μ , known σ |
| 8: | TInterval... | Confidence interval for 1 μ , unknown σ |
| 9: | 2-SampZInt... | Confidence interval for difference of 2 μ 's, known σ 's |
| 0: | 2-SampTInt... | Confidence interval for difference of 2 μ 's, unknown σ 's |
| A: | 1-PropZInt... | Confidence interval for 1 proportion |
| B: | 2-PropZInt... | Confidence interval for difference of 2 proportions |
| C: | χ^2 -Test... | Chi-square test for 2-way tables |
| D: | 2-SampFTest... | Test comparing 2 σ 's |

EDIT CALC TESTS

E: LinRegTTest... *t* test for regression slope and ρ

F: ANOVA(One-way analysis of variance

Note: When a new test or interval is computed, all previous output variables are invalidated.

Inferential Stat Editors for the STAT TESTS Instructions

In this chapter, the description of each **STAT TESTS** instruction shows the unique inferential stat editor for that instruction with example arguments.

- Descriptions of instructions that offer the **Data/Stats** input choice show both types of input screens.
- Descriptions of instructions that do not offer the **Data/Stats** input choice show only one input screen.

The description then shows the unique output screen for that instruction with the example results.

- Descriptions of instructions that offer the **Calculate/Draw** output choice show both types of screens: calculated and graphic results.
- Descriptions of instructions that offer only the **Calculate** output choice show the calculated results on the home screen.

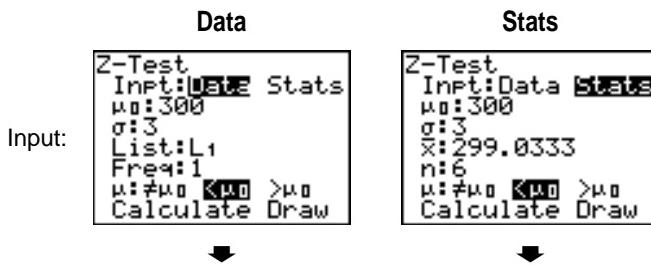
Z-Test

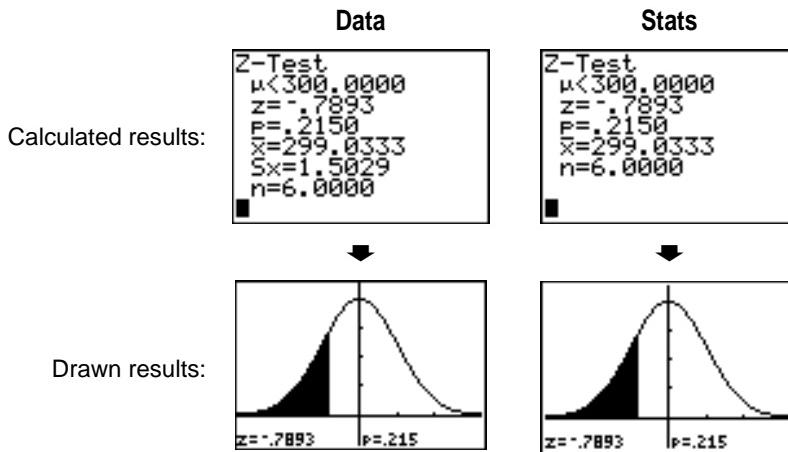
Z-Test (one-sample z test; item 1) performs a hypothesis test for a single unknown population mean μ when the population standard deviation σ is known. It tests the null hypothesis $H_0: \mu = \mu_0$ against one of the alternatives below.

- $H_a: \mu \neq \mu_0$ ($\mu: \neq \mu_0$)
- $H_a: \mu < \mu_0$ ($\mu: < \mu_0$)
- $H_a: \mu > \mu_0$ ($\mu: > \mu_0$)

In the example:

$$L1=\{299.4 \ 297.7 \ 301 \ 298.9 \ 300.2 \ 297\}$$





Note: All **STAT TESTS** examples assume a fixed-decimal mode setting of **4** (Chapter 1). If you set the decimal mode to **Float** or a different fixed-decimal setting, your output may differ from the output in the examples.

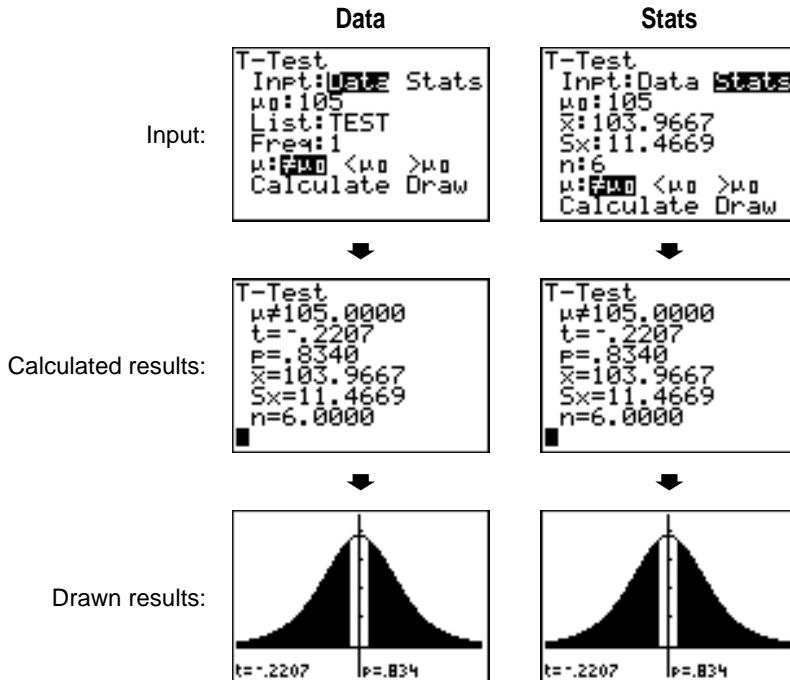
T-Test

T-Test (one-sample t test; item 2) performs a hypothesis test for a single unknown population mean μ when the population standard deviation σ is unknown. It tests the null hypothesis $H_0: \mu=\mu_0$ against one of the alternatives below.

- $H_a: \mu \neq \mu_0$ ($\mu \neq \mu_0$)
- $H_a: \mu < \mu_0$ ($\mu < \mu_0$)
- $H_a: \mu > \mu_0$ ($\mu > \mu_0$)

In the example:

TEST={91.9 97.8 111.4 122.3 105.4 95}



2-SampZTest

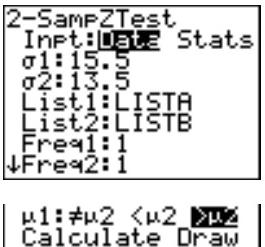
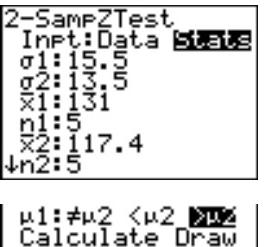
2-SampZTest (two-sample z test; item 3) tests the equality of the means of two populations (μ_1 and μ_2) based on independent samples when both population standard deviations (σ_1 and σ_2) are known. The null hypothesis $H_0: \mu_1=\mu_2$ is tested against one of the alternatives below.

- $H_a: \mu_1 \neq \mu_2$ ($\mu_1:\neq\mu_2$)
- $H_a: \mu_1 < \mu_2$ ($\mu_1:<\mu_2$)
- $H_a: \mu_1 > \mu_2$ ($\mu_1:>\mu_2$)

In the example:

LISTA={154 109 137 115 140}

LISTB={108 115 126 92 146}

| Data | Stats |
|---|---|
|  |  |

↓ ↓

Calculated results:

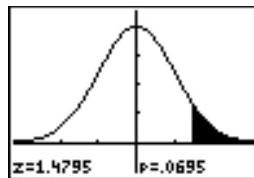
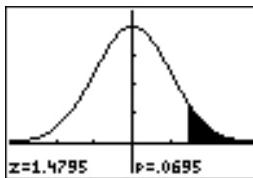
2-SampZTest
 $\mu_1 > \mu_2$
 $z=1.4795$
 $P=.0695$
 $\bar{x}_1=131.0000$
 $\bar{x}_2=117.4000$
 $\downarrow S_{x_1}=18.6145$

2-SampZTest
 $\mu_1 > \mu_2$
 $z=1.4795$
 $P=.0695$
 $\bar{x}_1=131.0000$
 $\bar{x}_2=117.4000$
 $\downarrow n_1=5.0000$

$S_{x_2}=20.1941$
 $n_1=5.0000$
 $n_2=5.0000$

$n_2=5.0000$

Drawn results:



2-SampTTest

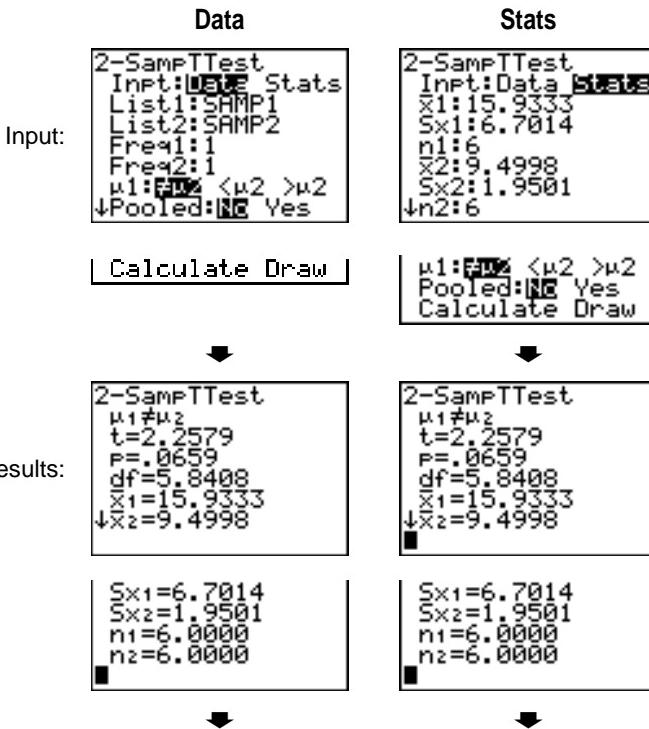
2-SampTTest (two-sample t test; item 4) tests the equality of the means of two populations (μ_1 and μ_2) based on independent samples when neither population standard deviation (σ_1 or σ_2) is known. The null hypothesis $H_0: \mu_1=\mu_2$ is tested against one of the alternatives below.

- $H_a: \mu_1 \neq \mu_2$ ($\mu_1: \neq \mu_2$)
- $H_a: \mu_1 < \mu_2$ ($\mu_1: < \mu_2$)
- $H_a: \mu_1 > \mu_2$ ($\mu_1: > \mu_2$)

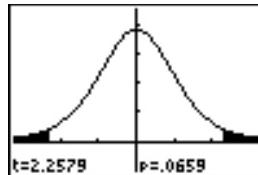
In the example:

SAMP1={12.207 16.869 25.05 22.429 8.456 10.589}

SAMP2={11.074 9.686 12.064 9.351 8.182 6.642}



Drawn results:



1-PropZTest

1-PropZTest (one-proportion z test; item 5) computes a test for an unknown proportion of successes (prop). It takes as input the count of successes in the sample x and the count of observations in the sample n . **1-PropZTest** tests the null hypothesis $H_0: \text{prop} = p_0$ against one of the alternatives below.

- $H_a: \text{prop} \neq p_0$ (**prop: \neq p0**)
- $H_a: \text{prop} < p_0$ (**prop:<p0**)
- $H_a: \text{prop} > p_0$ (**prop:>p0**)

Input:

| |
|------------------------------------|
| 1-PropZTest |
| P0:.5 |
| x:2048 |
| n:4040 |
| Prop P0 < p_0 > p_0 |
| Calculate Draw |

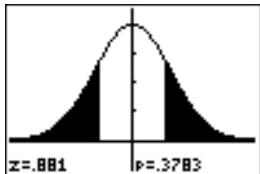


Calculated results:

```
1-PropZTest  
Prop#=.5000  
z=.8810  
P=.3783  
p=.5069  
n=4040.0000
```



Drawn results:



2-PropZTest

2-PropZTest (two-proportion z test; item 6) computes a test to compare the proportion of successes (p_1 and p_2) from two populations. It takes as input the count of successes in each sample (x_1 and x_2) and the count of observations in each sample (n_1 and n_2). **2-PropZTest** tests the null hypothesis $H_0: p_1=p_2$ (using the pooled sample proportion \hat{p}) against one of the alternatives below.

- $H_a: p_1 \neq p_2$ ($p1 \neq p2$)
- $H_a: p_1 < p_2$ ($p1 < p2$)
- $H_a: p_1 > p_2$ ($p1 > p2$)

Input:

```
2-PropZTest  
x1:45  
n1:61  
x2:38  
n2:62  
p1:p2 < p2  
Calculate Draw
```



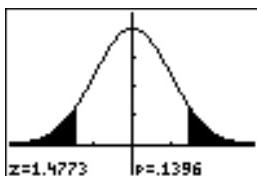
Calculated results:

```
2-PropZTest  
p1 ≠ p2  
z=1.4773  
P=.1396  
p̂1=.7377  
p̂2=.6129  
↓p̂=.6748
```

```
n1=61.0000  
n2=62.0000
```



Drawn results:

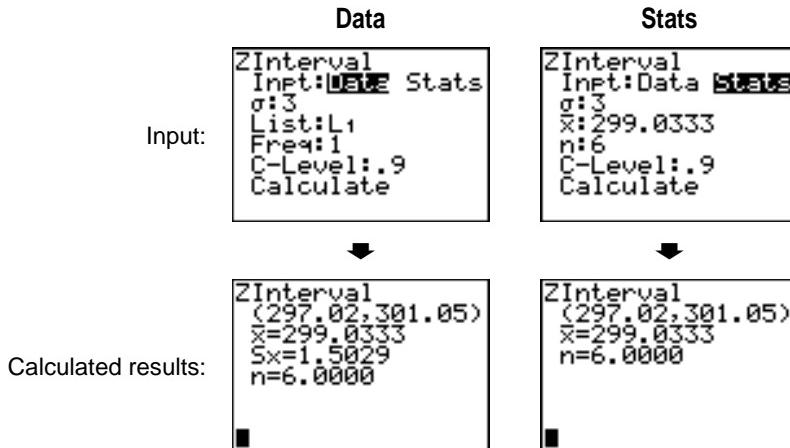


ZInterval

ZInterval (one-sample z confidence interval; item 7) computes a confidence interval for an unknown population mean μ when the population standard deviation σ is known. The computed confidence interval depends on the user-specified confidence level.

In the example:

$L1=\{299.4 \ 297.7 \ 301 \ 298.9 \ 300.2 \ 297\}$



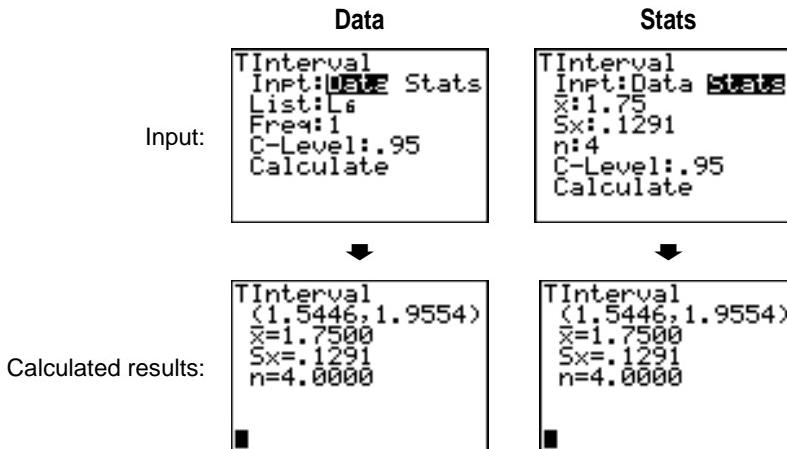
Calculated results:

TInterval

TInterval (one-sample t confidence interval; item 8) computes a confidence interval for an unknown population mean μ when the population standard deviation σ is unknown. The computed confidence interval depends on the user-specified confidence level.

In the example:

$L6=\{1.6 \text{ } 1.7 \text{ } 1.8 \text{ } 1.9\}$



2-SampZInt

2-SampZInt (two-sample z confidence interval; item 9) computes a confidence interval for the difference between two population means ($\mu_1 - \mu_2$) when both population standard deviations (σ_1 and σ_2) are known. The computed confidence interval depends on the user-specified confidence level.

In the example:

LISTC={154 109 137 115 140}

LISTD={108 115 126 92 146}

| Data | Stats |
|--|---|
| <pre>2-SampZInt Inpt:Data Stats σ1:15.5 σ2:13.5 List1:LISTC List2:LISTD Freq1:1 ↓Freq2:1</pre> | <pre>2-SampZInt Inpt:Data State σ1:15.5 σ2:13.5 x̄1:131 n1:5 x̄2:117.4 ↓n2:5</pre> |
| <pre>C-Level:.99 Calculate</pre> | <pre>C-Level:.99 Calculate</pre> |

↓ ↓

Calculated results:

```
2-SampZInt  
(-10.08,37.278)  
 $\bar{x}_1=131.0000$   
 $\bar{x}_2=117.4000$   
 $S_{x_1}=18.6145$   
 $S_{x_2}=20.1941$   
 $n_1=5.0000$   
 $n_2=5.0000$ 
```

```
2-SampZInt  
(-10.08,37.278)  
 $\bar{x}_1=131.0000$   
 $\bar{x}_2=117.4000$   
 $n_1=5.0000$   
 $n_2=5.0000$ 
```

```
|  $n_2=5.0000$ 
```

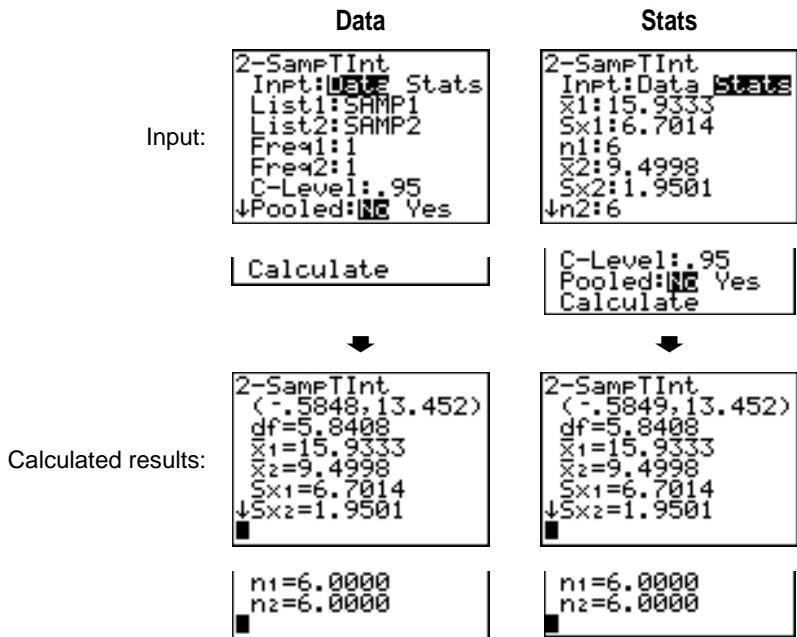
2-SampTInt

2-SampTInt (two-sample t confidence interval; item **0**) computes a confidence interval for the difference between two population means ($\mu_1 - \mu_2$) when both population standard deviations (σ_1 and σ_2) are unknown. The computed confidence interval depends on the user-specified confidence level.

In the example:

SAMP1={12.207 16.869 25.05 22.429 8.456 10.589}

SAMP2={11.074 9.686 12.064 9.351 8.182 6.642}



1-PropZInt

1-PropZInt (one-proportion z confidence interval; item A) computes a confidence interval for an unknown proportion of successes. It takes as input the count of successes in the sample x and the count of observations in the sample n . The computed confidence interval depends on the user-specified confidence level.

Input:

| |
|-------------|
| 1-PropZInt |
| x:2048 |
| n:4040 |
| C-Level:.99 |
| Calculate |



Calculated results:

| |
|-----------------|
| 1-PropZInt |
| (.4867,.5272) |
| $\hat{p}=.5069$ |
| n=4040.0000 |

2-PropZInt

2-PropZInt (two-proportion z confidence interval; item **B**) computes a confidence interval for the difference between the proportion of successes in two populations ($p_1 - p_2$). It takes as input the count of successes in each sample (x_1 and x_2) and the count of observations in each sample (n_1 and n_2). The computed confidence interval depends on the user-specified confidence level.

Input:

```
2-PropZInt
x1:49
n1:61
x2:38
n2:62
C-Level:.95
Calculate
```



Calculated results:

```
2-PropZInt
(.0334, .3474)
̂p1=.8033
̂p2=.6129
n1=61.0000
n2=62.0000
```

χ^2 -Test

χ^2 -Test (chi-square test; item C) computes a chi-square test for association on the two-way table of counts in the specified *Observed* matrix. The null hypothesis H_0 for a two-way table is: no association exists between row variables and column variables. The alternative hypothesis is: the variables are related.

Before computing a χ^2 -Test, enter the observed counts in a matrix. Enter that matrix variable name at the **Observed:** prompt in the χ^2 -Test editor; default=[A]. At the **Expected:** prompt, enter the matrix variable name to which you want the computed expected counts to be stored; default=[B].

Matrix editor:

```
MATRIX[A] 3 ×2
[ 5.0000 19.0000 ]
[ 8.0000 16.0000 ]
[ 11.0000 13.0000 ]
```

Input:

```
χ²-Test
Observed: [A]
Expected: [B]
Calculate Draw
```

Note: Press **2nd MATRIX**
► ► 1 to select **1:[A]**
from the MATRIX EDIT menu.

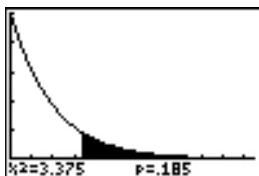
Note: Press [2nd] [MATRX]
[B] [ENTER] to display
matrix [B].

Calculated results:

χ^2 -Test
 $\chi^2 = 3.3750$
 $P = .1850$
 $df = 2.0000$

[B]
[[8.0000 16.000...
[8.0000 16.000...
[8.0000 16.000...
■

Drawn results:



2-SampFTest

2-SampFTest (two-sample F-test; item **D**) computes an F-test to compare two normal population standard deviations (σ_1 and σ_2). The population means and standard deviations are all unknown. **2-SampFTest**, which uses the ratio of sample variances $Sx1^2/Sx2^2$, tests the null hypothesis $H_0: \sigma_1=\sigma_2$ against one of the alternatives below.

- $H_a: \sigma_1 \neq \sigma_2$ ($\sigma_1 > \sigma_2$)
- $H_a: \sigma_1 < \sigma_2$ ($\sigma_1 < \sigma_2$)
- $H_a: \sigma_1 > \sigma_2$ ($\sigma_1 > \sigma_2$)

In the example:

```
SAMP4={ 7 -4 18 17 -3 -5 1 10 11 -2}  
SAMP5={ -1 12 -1 -3 3 -5 5 2 -11 -1 -3}
```

| Data | Stats |
|--|--|
| <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">2-SampFTest Inpt:Data Stats List1:SAMP4 List2:SAMP5 Freq1:1 Freq2:1 $\sigma_1:\text{F1}$ $<\sigma_2 >\sigma_2$ Calculate Draw</div> | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">2-SampFTest Inpt:Data Stats Sx1:8.7433 n1:10 Sx2:5.9007 n2:11 $\sigma_1:\text{F1}$ $<\sigma_2 >\sigma_2$ Calculate Draw</div> |

↓ ↓

Calculated results:

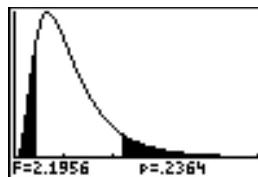
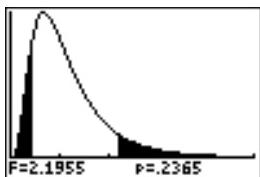
2-SampFTest
 $\sigma_1 \neq \sigma_2$
 $F=2.1955$
 $P=.2365$
 $Sx_1=8.7433$
 $Sx_2=5.9007$
 $\downarrow \bar{x}_1=5.0000$

2-SampFTest
 $\sigma_1 \neq \sigma_2$
 $F=2.1956$
 $P=.2364$
 $Sx_1=8.7433$
 $Sx_2=5.9007$
 $\downarrow n_1=10.0000$

$\bar{x}_2=-.2727$
 $n_1=10.0000$
 $n_2=11.0000$

$n_2=11.0000$

Drawn results:



LinRegTTest

LinRegTTest (linear regression t test; item **E**) computes a linear regression on the given data and a t test on the value of slope β and the correlation coefficient ρ for the equation $y=\alpha+\beta x$. It tests the null hypothesis $H_0: \beta=0$ (equivalently, $\rho=0$) against one of the alternatives below.

- $H_a: \beta \neq 0$ and $\rho \neq 0$ (β & $\rho \neq 0$)
- $H_a: \beta < 0$ and $\rho < 0$ (β & $\rho < 0$)
- $H_a: \beta > 0$ and $\rho > 0$ (β & $\rho > 0$)

The regression equation is automatically stored to **RegEQ** (VARS Statistics EQ secondary menu). If you enter a **Y=** variable name at the **RegEQ:** prompt, the calculated regression equation is automatically stored to the specified **Y=** equation. In the example below, the regression equation is stored to **Y1**, which is then selected (turned on).

In the example:

L3={ 38 56 59 64 74}

L4={ 41 63 70 72 84}

Input:
LinRegTTest
Xlist:L3
Ylist:L4
Freq:1
 $\beta \neq 0$: <0 >0
RegEQ:Y1
Calculate

Calculated results:

LinRegTTest
 $y = a + bx$
 $\beta \neq 0$ and $\rho \neq 0$
 $t = 15.9405$
 $P = 5.3684 \times 10^{-4}$
 $df = 3.0000$
 $\hat{a} = -3.6596$

Plot1 Plot2 Plot3
 $\checkmark Y_1 = -3.6596 + 1.19$
69X
 $\checkmark Y_2 =$
 $\checkmark Y_3 =$
 $\checkmark Y_4 =$
 $\checkmark Y_5 =$
 $\checkmark Y_6 =$

$\hat{b} = 1.1969$
 $s = 1.9820$
 $r^2 = .9883$
 $r = .9941$

When **LinRegTTest** is executed, the list of residuals is created and stored to the list name **RESID** automatically. **RESID** is placed on the **LIST NAMES** menu.

Note: For the regression equation, you can use the fix-decimal mode setting to control the number of digits stored after the decimal point (Chapter 1). However, limiting the number of digits to a small number could affect the accuracy of the fit.

ANOVA(

ANOVA((one-way analysis of variance; item F) computes a one-way analysis of variance for comparing the means of two to 20 populations. The **ANOVA** procedure for comparing these means involves analysis of the variation in the sample data. The null hypothesis $H_0: \mu_1=\mu_2=\dots=\mu_k$ is tested against the alternative $H_a: \text{not all } \mu_1\dots\mu_k \text{ are equal.}$

ANOVA(*list1, list2[, ..., list20]***)**

In the example:

L1={7 4 6 6 5}

L2={6 5 5 8 7}

L3={4 7 6 7 6}

ANOVA(L₁, L₂, L₃)■

Input:



One-way ANOVA
F=.3111
P=.7384
Factor
df=2.0000
SS=.9333
↓ MS=.4667
■

Calculated results:

Error
df=12.0000
SS=18.0000
MS=1.5000
SxP=1.2247
■

Note: SS is sum of squares and MS is mean square.

Inferential Statistics Input Descriptions

The tables in this section describe the inferential statistics inputs discussed in this chapter. You enter values for these inputs in the inferential stat editors. The tables present the inputs in the same order that they appear in this chapter.

| Input | Description |
|----------------------------------|---|
| μ_0 | Hypothesized value of the population mean that you are testing. |
| σ | The known population standard deviation; must be a real number > 0 . |
| List | The name of the list containing the data you are testing. |
| Freq | The name of the list containing the frequency values for the data in List . Default=1. All elements must be integers ≥ 0 . |
| Calculate/Draw | Determines the type of output to generate for tests and intervals. Calculate displays the output on the home screen. In tests, Draw draws a graph of the results. |
| \bar{x} , Sx , n | Summary statistics (mean, standard deviation, and sample size) for the one-sample tests and intervals. |
| σ_1 | The known population standard deviation from the first population for the two-sample tests and intervals. Must be a real number > 0 . |

| Input | Description |
|--|---|
| σ_2 | The known population standard deviation from the second population for the two-sample tests and intervals. Must be a real number > 0 . |
| List1, List2 | The names of the lists containing the data you are testing for the two-sample tests and intervals. Defaults are L1 and L2 , respectively. |
| Freq1, Freq2 | The names of the lists containing the frequencies for the data in List1 and List2 for the two-sample tests and intervals. Defaults=1. All elements must be integers ≥ 0 . |
| \bar{x}_1 , Sx1 , n_1 , \bar{x}_2 , Sx2 , n2 | Summary statistics (mean, standard deviation, and sample size) for sample one and sample two in the two-sample tests and intervals. |
| Pooled | Specifies whether variances are to be pooled for 2-SampTTest and 2-Samp TInt . No instructs the TI-83 not to pool the variances. Yes instructs the TI-83 to pool the variances. |
| p_0 | The expected sample proportion for 1-PropZTest . Must be a real number, such that $0 < p_0 < 1$. |
| x | The count of successes in the sample for the 1-PropZTest and 1-PropZInt . Must be an integer ≥ 0 . |
| n | The count of observations in the sample for the 1-PropZTest and 1-PropZInt . Must be an integer > 0 . |
| x1 | The count of successes from sample one for the 2-PropZTest and 2-PropZInt . Must be an integer ≥ 0 . |

| Input | Description |
|--------------------------|---|
| x2 | The count of successes from sample two for the 2-PropZTest and 2-PropZInt . Must be an integer ≥ 0 . |
| n1 | The count of observations in sample one for the 2-PropZTest and 2-PropZInt . Must be an integer > 0 . |
| n2 | The count of observations in sample two for the 2-PropZTest and 2-PropZInt . Must be an integer > 0 . |
| C-Level | The confidence level for the interval instructions. Must be ≥ 0 and < 100 . If it is ≥ 1 , it is assumed to be given as a percent and is divided by 100. Default=0.95. |
| Observed (Matrix) | The matrix name that represents the columns and rows for the observed values of a two-way table of counts for the χ^2 -Test. Observed must contain all integers ≥ 0 . Matrix dimensions must be at least 2×2 . |
| Expected (Matrix) | The matrix name that specifies where the expected values should be stored. Expected is created upon successful completion of the χ^2 -Test. |
| Xlist, Ylist | The names of the lists containing the data for LinRegTTest . Defaults are L1 and L2 , respectively. The dimensions of Xlist and Ylist must be the same. |
| RegEQ | The prompt for the name of the Y= variable where the calculated regression equation is to be stored. If a Y= variable is specified, that equation is automatically selected (turned on). The default is to store the regression equation to the RegEQ variable only. |

Test and Interval Output Variables

The inferential statistics variables are calculated as indicated below. To access these variables for use in expressions, press **VARS**, 5 (5:Statistics), and then select the **VARS** menu listed in the last column below.

| Variables | Tests | Intervals | LinRegTTest ANOVA | VARS Menu |
|--|------------------------|------------------------|----------------------|--------------|
| p-value | p | | p | TEST |
| test statistics | z, t, χ^2 , F | | t, F | TEST |
| degrees of freedom | df | df | df | TEST |
| sample mean of x values for sample 1 and sample 2 | \bar{x}_1, \bar{x}_2 | \bar{x}_1, \bar{x}_2 | | TEST |
| sample standard deviation of x for sample 1 and sample 2 | Sx1, Sx2 | Sx1, Sx2 | | TEST |
| number of data points for sample 1 and sample 2 | n1, n2 | n1, n2 | | TEST |
| pooled standard deviation | SxP | SxP | SxP | TEST |
| estimated sample proportion | \hat{p} | \hat{p} | | TEST |
| estimated sample proportion for population 1 | \hat{p}_1 | \hat{p}_1 | | TEST |
| estimated sample proportion for population 2 | \hat{p}_2 | \hat{p}_2 | | TEST |

| Variables | Tests | Intervals | LinRegTTest ANOVA | VARS Menu |
|--------------------------------|-----------|-----------------|----------------------|--------------|
| confidence interval pair | | lower, upper | | TEST |
| mean of x values | \bar{x} | \bar{x} | | XY |
| sample standard deviation of x | S_x | S_x | | XY |
| number of data points | n | n | | XY |
| standard error about the line | | | s | TEST |
| regression/fit coefficients | | | a, b | EQ |
| correlation coefficient | | | r | EQ |
| coefficient of determination | | | r ² | EQ |
| regression equation | | | RegEQ | EQ |

Note: The variables listed above cannot be archived.

Distribution Functions

DISTR menu

To display the DISTR menu, press **[2nd] [DISTR]**.

DISTR DRAW

| | |
|----------------|--|
| 1: normalpdf(| Normal probability density |
| 2: normalcdf(| Normal distribution probability |
| 3: invNorm(| Inverse cumulative normal distribution |
| 4: tpdf(| Student- <i>t</i> probability density |
| 5: tcdf(| Student- <i>t</i> distribution probability |
| 6: χ²pdf(| Chi-square probability density |
| 7: χ²cdf(| Chi-square distribution probability |
| 8: Fpdf(| F probability density |
| 9: Fcdf(| F distribution probability |
| 0: binompdf(| Binomial probability |
| A: binomcdf(| Binomial cumulative density |
| B: poissonpdf(| Poisson probability |
| C: poissoncdf(| Poisson cumulative density |
| D: geometpdf(| Geometric probability |
| E: geometcdf(| Geometric cumulative density |

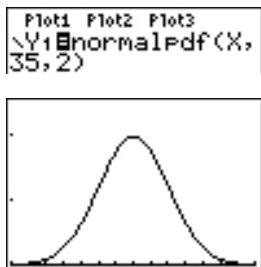
Note: -1E99 and 1E99 specify infinity. If you want to view the area left of *upperbound*, for example, specify *lowerbound*= -1E99.

normalpdf(

normalpdf(computes the probability density function (**pdf**) for the normal distribution at a specified x value. The defaults are mean $\mu=0$ and standard deviation $\sigma=1$. To plot the normal distribution, paste **normalpdf(** to the **Y=** editor. The probability density function (pdf) is:

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \sigma > 0$$

normalpdf($x[\mu,\sigma]$)



Note: For this example,
Xmin = 28
Xmax = 42
Ymin = 0
Ymax = .25

Tip: For plotting the normal distribution, you can set window variables **Xmin** and **Xmax** so that the mean μ falls between them, and then select **0:ZoomFit** from the **ZOOM** menu.

normalcdf(

normalcdf(computes the normal distribution probability between *lowerbound* and *upperbound* for the specified mean μ and standard deviation σ . The defaults are $\mu=0$ and $\sigma=1$.

normalcdf(*lowerbound,upperbound[,μ,σ]*)

```
normalcdf(-1e99,  
36,35,2)  
.6914624678
```

invNorm(

invNorm(computes the inverse cumulative normal distribution function for a given *area* under the normal distribution curve specified by mean μ and standard deviation σ . It calculates the *x* value associated with an *area* to the left of the *x* value. $0 \leq \text{area} \leq 1$ must be true. The defaults are $\mu=0$ and $\sigma=1$.

invNorm(*area[,μ,σ]*)

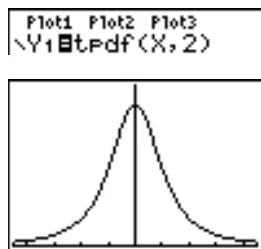
```
invNorm(.6914624  
678,35,2)  
36.00000004
```

tpdf(

tpdf(computes the probability density function (pdf) for the Student-*t* distribution at a specified *x* value. *df* (degrees of freedom) must be >0. To plot the Student-*t* distribution, paste **tpdf(** to the **Y=** editor. The probability density function (pdf) is:

$$f(x) = \frac{\Gamma[(df + 1)/2]}{\Gamma(df/2)} \cdot \frac{(1 + x^2/df)^{-(df + 1)/2}}{\sqrt{\pi df}}$$

tpdf(*x,df*)



Note: For this example,

Xmin = -4.5

Xmax = 4.5

Ymin = 0

Ymax = .4

tcdf(

tcdf(computes the Student-*t* distribution probability between *lowerbound* and *upperbound* for the specified *df* (degrees of freedom), which must be > 0.

tcdf(lowerbound,upperbound,df)

```
tcdf(-2,3,18)  
.9657465644
```

χ²pdf(

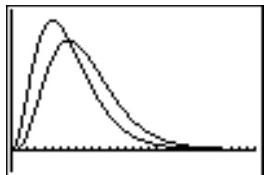
χ²pdf(computes the probability density function (pdf) for the χ^2 (chi-square) distribution at a specified x value. df (degrees of freedom) must be an integer > 0 . To plot the χ^2 distribution, paste **χ²pdf(** to the **Y=** editor. The probability density function (pdf) is:

$$f(x) = \frac{1}{\Gamma(df/2)} (1/2)^{df/2} x^{df/2 - 1} e^{-x/2}, x \geq 0$$

χ²pdf(x, df)

```
Plot1 Plot2 Plot3  
Y1=X²Pdf(X,9)  
Y2=X²Pdf(X,7)  
Y3=  
Y4=  
Y5=  
Y6=  
Y7=
```

Note: For this example,
Xmin = 0
Xmax = 30
Ymin = -.02
Ymax = .132



χ^2 cdf(

χ^2 cdf(computes the χ^2 (chi-square) distribution probability between *lowerbound* and *upperbound* for the specified *df* (degrees of freedom), which must be an integer > 0 .

χ^2 cdf(*lowerbound,upperbound,df*)

```
|χ²cdf(0,19.023,9  
|  
|.9750019601|
```

Fpdf(

Fpdf(computes the probability density function (pdf) for the F distribution at a specified *x* value. *numerator df* (degrees of freedom) and *denominator df* must be integers > 0 . To plot the F distribution, paste Fpdf(to the Y= editor. The probability density function (pdf) is:

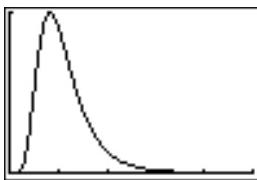
$$f(x) = \frac{\Gamma[(n+d)/2]}{\Gamma(n/2)\Gamma(d/2)} \left(\frac{n}{d}\right)^{n/2} x^{n/2-1} (1+nx/d)^{-(n+d)/2}, x \geq 0$$

where *n* = numerator degrees of freedom

d = denominator degrees of freedom

Fpdf(x , numerator df , denominator df)

```
Plot1 Plot2 Plot3  
>Y1: Fpdf(X, 24, 19)  
>
```



Note: For this example,

Xmin = 0

Xmax = 5

Ymin = 0

Ymax = 1

Fcdf(

Fcdf(computes the F distribution probability between *lowerbound* and *upperbound* for the specified *numerator df* (degrees of freedom) and *denominator df*. *numerator df* and *denominator df* must be integers >0.

Fcdf(*lowerbound,upperbound,numerator df,denominator df*)

```
Fcdf(0, 2.4523, 24  
, 19)  
.9749989576
```

binompdf

binompdf(computes a probability at x for the discrete binomial distribution with the specified *numtrials* and probability of success (p) on each trial. x can be an integer or a list of integers. $0 \leq p \leq 1$ must be true. *numtrials* must be an integer > 0 . If you do not specify x , a list of

probabilities from 0 to *numtrials* is returned. The probability density function (pdf) is:

$$f(x) = \binom{n}{x} p^x (1-p)^{n-x}, x = 0, 1, \dots, n$$

where $n = \text{numtrials}$

binompdf(*numtrials*,*p*[,*x*])

```
binompdf(5,.6,{3  
,4,5})  
.3456 .2592 .0...
```

binomcdf(*numtrials*,*p*[,*x*])

binomcdf(*numtrials*,*p*[,*x*]) computes a cumulative probability at *x* for the discrete binomial distribution with the specified *numtrials* and probability of success (*p*) on each trial. *x* can be a real number or a list of real numbers. $0 \leq p \leq 1$ must be true. *numtrials* must be an integer > 0 . If you do not specify *x*, a list of cumulative probabilities is returned.

binomcdf(*numtrials*,*p*[,*x*])

```
binomcdf(5,.6,{3  
,4,5})  
.66304 .92224 ...
```

poissonpdf(

poissonpdf(computes a probability at x for the discrete Poisson distribution with the specified mean μ , which must be a real number > 0 . x can be an integer or a list of integers. The probability density function (pdf) is:

$$f(x) = e^{-\mu} \mu^x / x!, x = 0, 1, 2, \dots$$

poissonpdf(μ, x)

```
PoissonPdf(6,10)  
.0413030934
```

poissoncdf(

poissoncdf(computes a cumulative probability at x for the discrete Poisson distribution with the specified mean μ , which must be a real number > 0 . x can be a real number or a list of real numbers.

poissoncdf(μ, x)

```
Poissoncdf(.126,  
{0,1,2,3})  
.8816148468 .9...
```

geometpdf(

geometpdf(computes a probability at x , the number of the trial on which the first success occurs, for the discrete geometric distribution with the specified probability of success p . $0 \leq p \leq 1$ must be true. x can be an integer or a list of integers. The probability density function (pdf) is:

$$f(x) = p(1-p)^{x-1}, x = 1, 2, \dots$$

geometpdf(p, x)

```
geometpdf(.4, 6)  
.031104
```

geometcdf(

geometcdf(computes a cumulative probability at x , the number of the trial on which the first success occurs, for the discrete geometric distribution with the specified probability of success p . $0 \leq p \leq 1$ must be true. x can be a real number or a list of real numbers.

geometcdf(p, x)

```
geometcdf(.5, {1,  
2,3})  
.5 .75 .875
```

Distribution Shading

DISTR DRAW Menu

To display the **DISTR DRAW** menu, press **[2nd] [DISTR]** **[▶]**. **DISTR DRAW** instructions draw various types of density functions, shade the area specified by *lowerbound* and *upperbound*, and display the computed area value.

To clear the drawings, select **1:ClrDraw** from the **DRAW** menu (Chapter 8).

Note: Before you execute a **DISTR DRAW** instruction, you must set the window variables so that the desired distribution fits the screen.

DISTR DRAW

- | | |
|---------------|--|
| 1: ShadeNorm(| Shades normal distribution. |
| 2: Shade_t(| Shades Student- <i>t</i> distribution. |
| 3: Shadeχ²(| Shades χ^2 distribution. |
| 4: ShadeF(| Shades F distribution. |
-

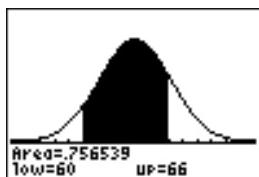
Note: -1E99 and 1E99 specify infinity. If you want to view the area left of *upperbound*, for example, specify *lowerbound*=-1E99.

ShadeNorm(

ShadeNorm(draws the normal density function specified by mean μ and standard deviation σ and shades the area between *lowerbound* and *upperbound*. The defaults are $\mu=0$ and $\sigma=1$.

ShadeNorm(lowerbound,upperbound[, μ , σ])

```
ShadeNorm(60,66,  
63.6,2.5)■
```



Note: For this example,

Xmin = 55

Xmax = 72

Ymin = -.05

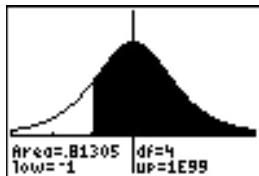
Ymax = .2

Shade_t(

Shade_t(draws the density function for the Student-*t* distribution specified by *df* (degrees of freedom) and shades the area between *lowerbound* and *upperbound*.

Shade_t(*lowerbound,upperbound,df*)

```
Shade_t(-1,1e99,  
4)■
```



Note: For this example,

Xmin = -3

Xmax = 3

Ymin = -.15

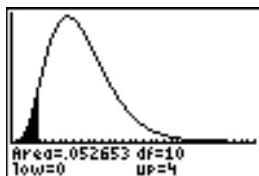
Ymax = .5

Shade χ^2 (*lowerbound,upperbound,df*)

Shade χ^2 (draws the density function for the χ^2 (chi-square) distribution specified by *df* (degrees of freedom) and shades the area between *lowerbound* and *upperbound*.

Shade χ^2 (*lowerbound,upperbound,df*)

```
Shadeχ²(0, 4, 10)■
```



Note: For this example,

Xmin = 0

Xmax = 35

Ymin = -.025

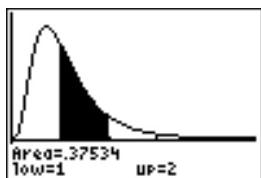
Ymax = .1

ShadeF(

ShadeF(draws the density function for the F distribution specified by *numerator df* (degrees of freedom) and *denominator df* and shades the area between *lowerbound* and *upperbound*.

ShadeF(lowerbound,upperbound,numerator df,denominator df)

```
ShadeF(1,2,10,15)
```



Note: For this example,

Xmin = 0

Xmax = 5

Ymin = -.25

Ymax = .9

Chapter 14: **Applications**

The Applications Menu

The TI-83 Plus comes with **Finance** and **CBL/CBR** applications already listed on the **APPLICATIONS** menu. Except for the **Finance** application, you can add and remove applications as space permits. The **Finance** application is built into the TI-83 Plus code and cannot be deleted.

You can buy additional TI-83 Plus software applications that allow you to customize further your calculator's functionality. The calculator reserves 1.54 M of space within ROM memory specifically for applications.

Your TI-83 Plus includes Flash applications in addition to the ones mentioned above. Press **[APPS]** to see the complete list of applications that came with your calculator.

Documentation for TI Flash applications is on the TI Resource CD. Visit education.ti.com/guides for additional Flash application guidebooks.

Steps for Running the Finance Application

Follow these basic steps when using the **Finance** application.

Select the Finance application.

Press **APPS** **[ENTER]**.

Select from list of functions.

APPLICATIONS
1:Finance...
2:CBL/CBR

FIN VARS
1:TVM_Solver...
2:tvm_Pmt
3:tvm_I%
4:tvm_PV
5:tvm_N
6:tvm_FV
7↓nPV(

Getting Started: Financing a Car

Getting Started is a fast-paced introduction. Read the chapter for details.

You have found a car you would like to buy. The car costs 9,000. You can afford payments of 250 per month for four years. What annual percentage rate (APR) will make it possible for you to afford the car?

1. Press **MODE** \blacktriangleleft \blacktriangleright \blacktriangleright \blacktriangleright **ENTER** to set the fixed-decimal mode setting to 2. The TI-83 Plus will display all numbers with two decimal places).

Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^@i
Full Horiz G-T

2. Press **APPS** **ENTER** to select **1:Finance** from the **APPLICATIONS** menu.

CALC VARS
1:TVM Solver...
2:tvm_Pmt
3:tvm_I%
4:tvm_PV
5:tvm_N
6:tvm_FV
7:npv<

3. Press **ENTER** to select **1:TVM Solver** from the **CALC VARS** menu. The **TVM Solver** is displayed.

Press **48** **ENTER** to store 48 months to **N**. Press **9000** **ENTER** to store 9,000 to **PV**. Press **(-)** **250** **ENTER** to store -250 to **PMT**. (Negation indicates cash outflow.) Press **0** **ENTER** to store 0 to **FV**.

N=48.00
I%=.00
PV=9000
PMT=-250
FV=0.00
P/Y=1.00
C/Y=1.00
PMT: **END** **BEGIN**

Press **12** [ENTER] to store 12 payments per year to **P/Y** and 12 compounding periods per year to **C/Y**. Setting **P/Y** to 12 will compute an annual percentage rate (compounded monthly) for **I%**. Press **▼** [ENTER] to select **PMT:END**, which indicates that payments are due at the end of each period.

4. Press **▲ ▲ ▲ ▲ ▲ ▲** to move the cursor to the **I%** prompt. Press **[ALPHA] [SOLVE]** to solve for **I%**. What APR should you look for?

```
N=48.00
I%=.00
PV=9000.00
PMT=-250.00
FV=0.00
P/Y=12.00
C/Y=12.00
PMT:END BEGIN
```

```
N=48.00
• I% = 14.90
PV=9000.00
PMT=-250.00
FV=0.00
P/Y=12.00
C/Y=12.00
PMT:END BEGIN
```

Getting Started: Computing Compound Interest

At what annual interest rate, compounded monthly, will 1,250 accumulate to 2,000 in 7 years?

Note: Because there are no payments when you solve compound interest problems, PMT must be set to 0 and P/Y must be set to 1.

1. Press **[APPS]** **[ENTER]** to select 1:Finance from the **APPLICATIONS** menu.

The screen shows the TI-Nspire CX CAS Applications menu. The first item, "1:TVM Solver...", is highlighted with a blue border. Other options include 2:tvm_Pmt, 3:tvm_I%, 4:tvm_PV, 5:tvm_N, 6:tvm_FV, and 7:npv(<). The bottom right corner shows a small "APPS" icon.

2. Press **[ENTER]** to select 1:TVM Solver from the **CALC VARS** menu. The **TVM Solver** is displayed. Press 7 to enter the number of periods in years. Press **[▼] [▼] [→] 1250** to enter the present value as a cash outflow (investment). Press **[▼] 0** to specify no payments. Press **[▼] 2000** to enter the future value as a cash inflow (return). Press **[▼] 1** to enter payment periods per year. Press **[▼] 12** to set compounding periods per year to 12.

The screen shows the TVM Solver input fields. The values entered are: N=7, I%=0, PV=-1250, PMT=0, FV=2000, P/Y=1, C/Y=12, and PMT:END. The "BEGIN" option is also visible. The bottom right corner shows a small "APPS" icon.

3. Press $\boxed{\Delta}$ $\boxed{\Delta}$ $\boxed{\Delta}$ $\boxed{\Delta}$ $\boxed{\Delta}$ to place the cursor on the I% prompt.

```
N=7  
I%=  
PV=-1250  
PMT=0  
FV=2000  
P/Y=1  
C/Y=12  
PMT:END BEGIN
```

4. Press **[ALPHA]** **[SOLVE]** to solve for I%, the annual interest rate.

```
N=7.00  
I%=6.73  
PV=-1250.00  
PMT=0.00  
FV=2000.00  
P/Y=1.00  
C/Y=12.00  
PMT:END BEGIN
```

Using the TVM Solver

Using the TVM Solver

The **TVM Solver** displays the time-value-of-money (**TVM**) variables. Given four variable values, the **TVM Solver** solves for the fifth variable.

The [FINANCE VARS](#) menu section describes the five **TVM** variables (**N**, **I%**, **PV**, **PMT**, and **FV**) and **P/Y** and **C/Y**.

PMT: END BEGIN in the **TVM Solver** corresponds to the **FINANCE CALC** menu items **Pmt_End** (payment at the end of each period) and **Pmt_Bgn** (payment at the beginning of each period).

To solve for an unknown **TVM** variable, follow these steps.

1. Press **[APPS]** **[ENTER]** **[ENTER]** to display the **TVM Solver**. The screen below shows the default values with the fixed-decimal mode set to two decimal places.

| |
|----------------------|
| N=0.00 |
| I%=0.00 |
| PV=0.00 |
| PMT=0.00 |
| FV=0.00 |
| P/Y=1.00 |
| C/Y=1.00 |
| PMT:END BEGIN |

2. Enter the known values for four **TVM** variables.
- Note:** Enter cash inflows as positive numbers and cash outflows as negative numbers.
3. Enter a value for **P/Y**, which automatically enters the same value for **C/Y**; if **P/Y** ≠ **C/Y**, enter a unique value for **C/Y**.
4. Select **END** or **BEGIN** to specify the payment method.
5. Place the cursor on the **TVM** variable for which you want to solve.
6. Press **[ALPHA] [SOLVE]**. The answer is computed, displayed in the **TVM Solver**, and stored to the appropriate **TVM** variable. An indicator square in the left column designates the solution variable.

| |
|-----------------------|
| N=360.00 |
| I%=18.00 |
| PV=1000000.00 |
| ■ PMT=-1507.09 |
| FV=0.00 |
| P/Y=12.00 |
| C/Y=12.00 |
| PMT: END BEGIN |

Using the Financial Functions

Entering Cash Inflows and Cash Outflows

When using the TI-83 Plus financial functions, you must enter cash inflows (cash received) as positive numbers and cash outflows (cash paid) as negative numbers. The TI-83 Plus follows this convention when computing and displaying answers.

FINANCE CALC Menu

To display the FINANCE CALC menu, press **[APPS]** **[ENTER]**.

| | |
|------------------|---|
| CALC | VARS |
| 1: TVM Solver... | Displays the TVM Solver . |
| 2: tvm_Pmt | Computes the amount of each payment. |
| 3: tvm_I% | Computes the interest rate per year. |
| 4: tvm_PV | Computes the present value. |
| 5: tvm_N | Computes the number of payment periods. |
| 6: tvm_FV | Computes the future value. |
| 7: npv(| Computes the net present value. |
| 8: irr(| Computes the internal rate of return. |
| 9: bal(| Computes the amortization sched. balance. |
| 0: ΣPrn(| Computes the amort. sched. princ. sum. |
| A: ΣInt(| Computes the amort. sched. interest sum. |

CALC **VARS**

- | | |
|------------|--|
| B: ►Nom(| Computes the nominal interest rate. |
| C: ►Eff(| Computes the effective interest rate. |
| D: dbd(| Calculates the days between two dates. |
| E: Pmt_End | Selects ordinary annuity (end of period). |
| F: Pmt_Bgn | Selects annuity due (beginning of period). |
-

Use these functions to set up and perform financial calculations on the home screen.

TVM Solver

TVM Solver displays the [**TVM Solver**](#).

Calculating Time Value of Money (TVM)

Calculating Time Value of Money

Use time-value-of-money (**TVM**) functions (menu items **2** through **6**) to analyze financial instruments such as annuities, loans, mortgages, leases, and savings.

Each **TVM** function takes zero to six arguments, which must be real numbers. The values that you specify as arguments for these functions are not stored to the [**TVM variables**](#).

Note: To store a value to a **TVM** variable, use the [**TVM Solver**](#) or use **STO** and any **TVM** variable on the **FINANCE VARS** menu.

If you enter less than six arguments, the TI-83 Plus substitutes a previously stored **TVM** variable value for each unspecified argument.

If you enter any arguments with a **TVM** function, you must place the argument or arguments in parentheses.

tvm_Pmt

tvm_Pmt computes the amount of each payment.

tvm_Pmt[(N,I%,PV,FV,P/Y,C/Y)]

```
N=360  
I%=.8.5  
PV=100000  
PMT=0  
FV=0  
P/Y=12  
C/Y=12  
PMT:END BEGIN
```

| | |
|-------------------------|---------|
| tvm_Pmt | -768.91 |
| tvm_Pmt(360,9.5) | -840.85 |

Note: In the example above, the values are stored to the **TVM** variables in the **TVM Solver**. Then the payment (**tvm_Pmt**) is computed on the home screen using the values in the **TVM Solver**. Next, the interest rate is changed to 9.5 to illustrate the effect on the payment amount.

tvm_I%

tvm_I% computes the annual interest rate.

tvm_I%[(N,PV,PMT,FV,P/Y,C/Y)]

```
tvm_I%(48,10000,  
-250,0,12) 9.24  
Ans→I% 9.24
```

tvm_PV

tvm_PV computes the present value.

tvm_PV[(N,I%,PMT,FV,P/Y,C/Y)]

| | |
|---|--------------------|
| 360→N:11→I%:-100 0→PMT:0→FV:12→P/Y tvm_PV | 12.00 105006.35 |
|---|--------------------|

tvm_N

tvm_N computes the number of payment periods.

tvm_N[(I%,PV,PMT,FV,P/Y,C/Y)]

| | |
|---|---------------|
| 6→I%:9000→PV:-35 0→PMT:0→FV:3→P/Y tvm_N | 3.00 36.47 |
|---|---------------|

tvm_FV

tvm_FV computes the future value.

tvm_FV[(N,I%,PV,PMT,P/Y,C/Y)]

```
6→N:8→I%:-5500→PV  
0→PMT:1→P/Y  
1.00  
tvm_FV      8727.81
```

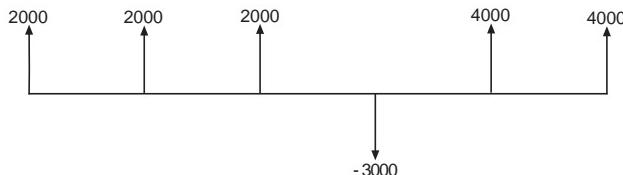
Calculating Cash Flows

Calculating a Cash Flow

Use the cash flow functions (menu items 7 and 8) to analyze the value of money over equal time periods. You can enter unequal cash flows, which can be cash inflows or outflows. The syntax descriptions for `npv()` and `irr()` use these arguments.

- *interest rate* is the rate by which to discount the cash flows (the cost of money) over one period.
- *CF0* is the initial cash flow at time 0; it must be a real number.
- *CFList* is a list of cash flow amounts after the initial cash flow *CF0*.
- *CFFreq* is a list in which each element specifies the frequency of occurrence for a grouped (consecutive) cash flow amount, which is the corresponding element of *CFList*. The default is 1; if you enter values, they must be positive integers < 10,000.

For example, express this uneven cash flow in lists.



$$CF0 = 2000$$

$$CFList = \{2000, -3000, 4000\}$$

$$CFFreq = \{2, 1, 2\}$$

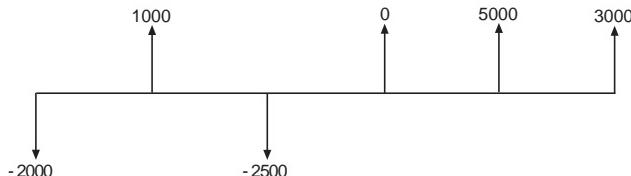
npv(, irr(

npv (net present value) is the sum of the present values for the cash inflows and outflows. A positive result for **npv** indicates a profitable investment.

npv(*interest rate, CF0, CFList[, CFFreq]*)

irr (internal rate of return) is the interest rate at which the net present value of the cash flows is equal to zero.

irr(*CF0, CFList[, CFFreq]*)



| |
|---|
| {1000, -2500, 0, 5000, 3000} → L ₁ |
| {1000.00 -2500.00...} |

| |
|--------------------------------|
| npv(6, -2000, L ₁) |
| 2920.65 |
| irr(-2000, L ₁) |
| 27.88 |

Calculating Amortization

Calculating an Amortization Schedule

Use the amortization functions (menu items **9**, **0**, and **A**) to calculate balance, sum of principal, and sum of interest for an amortization schedule.

bal(

bal(computes the balance for an amortization schedule using stored values for **I%**, **PV**, and **PMT**. *npmt* is the number of the payment at which you want to calculate a balance. It must be a positive integer < 10,000. *roundvalue* specifies the internal precision the calculator uses to calculate the balance; if you do not specify *roundvalue*, then the TI-83 Plus uses the current **Float/Fix** decimal-mode setting.

bal(npmt[,roundvalue])

```
1000000→PV:8.5→I%  
:-768.91→PMT:12→  
P/Y  
12.00
```

```
bal(12) 99244.07
```

$\Sigma\text{Prn}($, $\Sigma\text{Int}($

$\Sigma\text{Prn}($ computes the sum of the principal during a specified period for an amortization schedule using stored values for **I%**, **PV**, and **PMT**. *pmt1* is the starting payment. *pmt2* is the ending payment in the range. *pmt1* and *pmt2* must be positive integers < 10,000. *roundvalue* specifies the internal precision the calculator uses to calculate the principal; if you do not specify *roundvalue*, the TI-83 Plus uses the current **Float/Fix** decimal-mode setting.

Note: You must enter values for **I%**, **PV**, **PMT**, and before computing the principal.

$\Sigma\text{Prn}(pmt1,pmt2[,roundvalue])$

$\Sigma\text{Int}($ computes the sum of the interest during a specified period for an amortization schedule using stored values for **I%**, **PV**, and **PMT**. *pmt1* is the starting payment. *pmt2* is the ending payment in the range. *pmt1* and *pmt2* must be positive integers < 10,000. *roundvalue* specifies the internal precision the calculator uses to calculate the interest; if you do not specify *roundvalue*, the TI-83 Plus uses the current **Float/Fix** decimal-mode setting.

$\Sigma\text{Int}(pmt1,pmt2[,roundvalue])$

| |
|--|
| $360 \rightarrow N: 1000000 \rightarrow PV:$ |
| $8.5 \rightarrow I\%: -768.91 \rightarrow P$ |
| $MT: 12 \rightarrow P/Y$ |
| 12.00 |

| | |
|---------------------------|----------|
| $\Sigma\text{Prn}(1, 12)$ | -755.93 |
| $\Sigma\text{Int}(1, 12)$ | -8470.99 |

Amortization Example: Calculating an Outstanding Loan Balance

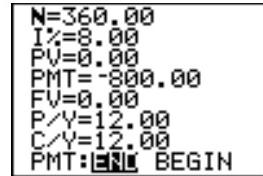
You want to buy a home with a 30-year mortgage at 8 percent APR. Monthly payments are 800. Calculate the outstanding loan balance after each payment and display the results in a graph and in the table.

1. Press **MODE**. Press $\blacktriangleleft \blacktriangleright \blacktriangleright \blacktriangleright$ **ENTER** to set the fixed-decimal mode setting to 2. Press $\blacktriangleleft \blacktriangleright \blacktriangleright$ **ENTER** to select **Par** graphing mode.



Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^@i
Full Horiz G-T

2. Press **APPS** **ENTER** **ENTER** to display the **TVM Solver**.
3. Press **ENTER** **360** to enter number of payments. Press \blacktriangleleft **8** to enter the interest rate. Press $\blacktriangleleft \blacktriangleright$ **0** to enter the future value of the mortgage. Press \blacktriangleleft **12** to enter the payments per year, which also sets the compounding periods per year to **12**. Press $\blacktriangleleft \blacktriangleright$ **ENTER** to select **PMT:END**.



N=360.00
I% = 8.00
PV = 0.00
PMT = -800.00
FV = 0.00
P/Y = 12.00
C/Y = 12.00
PMT:END BEGIN

4. Press $\blacktriangle \blacktriangle \blacktriangle \blacktriangle \blacktriangle$ to place the cursor on the PV prompt. Press [ALPHA] [SOLVE] to solve for the present value.

```
N=360.00  
I%={8.00  
PV=109026.80  
PMT= -800.00  
FV=0.00  
P/Y=12.00  
C/Y=12.00  
PMT:{END BEGIN}
```

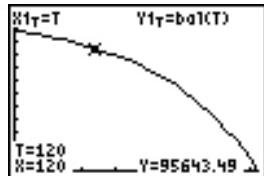
5. Press **[Y=]** to display the parametric Y= editor. Turn off all stat plots. Press **[X,T,θ,n]** to define X_1T as T. Press \blacktriangledown [APPS] [ENTER] 9 **[X,T,θ,n]** to define Y_1T as $bal(T)$.

```
Plot1 Plot2 Plot3  
Y1T:BT  
Y1T:bal(T)
```

6. Press **[WINDOW]** to display the window variables. Enter the values below.

| | | |
|----------|----------|-------------|
| Tmin=0 | Xmin=0 | Ymin=0 |
| Tmax=360 | Xmax=360 | Ymax=125000 |
| Tstep=12 | Xscl=50 | Yscl=10000 |

7. Press **[TRACE]** to draw the graph and activate the trace cursor. Press \blacktriangleright and \blacktriangleleft to explore the graph of the outstanding balance over time. Press a number and then press **[ENTER]** to view the balance at a specific time T.



8. Press **[2nd] [TBLSET]** and enter the values below.

TblStart=0

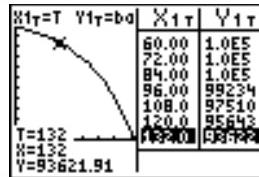
ΔTbl=12

9. Press **2nd** [TABLE] to display the table of outstanding balances (Y_{1T}).

| T | X _{1T} | Y _{1T} |
|-------|-----------------|-----------------|
| 0.00 | 0.00 | 109027 |
| 12.00 | 12.00 | 108116 |
| 24.00 | 24.00 | 107130 |
| 36.00 | 36.00 | 106061 |
| 48.00 | 48.00 | 104905 |
| 60.00 | 60.00 | 103852 |
| 72.00 | 72.00 | 102295 |
| T=0 | | |

10. Press **MODE** **ENTER** to select **G-T** split-screen mode, in which the graph and table are displayed simultaneously.

Press **TRACE** to display X_{1T} (time) and Y_{1T} (balance) in the table.



Calculating Interest Conversion

Calculating an Interest Conversion

Use the interest conversion functions (menu items **B** and **C**) to convert interest rates from an annual effective rate to a nominal rate (**►Nom(**) or from a nominal rate to an annual effective rate (**►Eff(**).

►Nom(

►Nom(computes the nominal interest rate. *effective rate* and *compounding periods* must be real numbers. *compounding periods* must be >0 .

►Nom(*effective rate,compounding periods*)

```
►Nom(15.87,4)  
15.00
```

►Eff(

►Eff(computes the effective interest rate. *nominal rate* and *compounding periods* must be real numbers. *compounding periods* must be >0 .

►Eff(*nominal rate,compounding periods*)

```
►Eff(8,12)  
8.30
```

Finding Days between Dates/Defining Payment Method

dbd(

Use the date function **dbd(** (menu item **D**) to calculate the number of days between two dates using the actual-day-count method. *date1* and *date2* can be numbers or lists of numbers within the range of the dates on the standard calendar.

Note: Dates must be between the years 1950 through 2049.

dbd(*date1*,*date2*)

You can enter *date1* and *date2* in either of two formats.

- MM.DDYY (United States)
- DDMM.YY (Europe)

The decimal placement differentiates the date formats.

```
dbd(12.3190,12.3  
192)      731.00
```

Defining the Payment Method

Pmt_End and **Pmt_Bgn** (menu items **E** and **F**) specify a transaction as an ordinary annuity or an annuity due. When you execute either command, the **TVM Solver** is updated.

Pmt_End

Pmt_End (payment end) specifies an ordinary annuity, where payments occur at the end of each payment period. Most loans are in this category. **Pmt_End** is the default.

Pmt_End

On the **TVM Solver's PMT:END BEGIN** line, select **END** to set **PMT** to ordinary annuity.

Pmt_Bgn

Pmt_Bgn (payment beginning) specifies an annuity due, where payments occur at the beginning of each payment period. Most leases are in this category.

Pmt_Bgn

On the **TVM Solver's PMT:END BEGIN** line, select **BEGIN** to set **PMT** to annuity due.

Using the TVM Variables

FINANCE VARS Menu

To display the **FINANCE VARS** menu, press **[APPS]** **[ENTER]** **[▶]**. You can use **TVM** variables in **TVM** functions and store values to them on the home screen.

CALC VARS

- | | |
|----------------|------------------------------------|
| 1 : N | Total number of payment periods |
| 2 : I% | Annual interest rate |
| 3 : PV | Present value |
| 4 : PMT | Payment amount |
| 5 : FV | Future value |
| 6 : P/Y | Number of payment periods per year |
| 7 : C/Y | Number of compounding periods/year |
-

N, I%, PV, PMT, FV

N, I%, PV, PMT, and **FV** are the five **TVM** variables. They represent the elements of common financial transactions, as described in the table above. **I%** is an annual interest rate that is converted to a per-period rate based on the values of **P/Y** and **C/Y**.

P/Y and C/Y

P/Y is the number of payment periods per year in a financial transaction.

C/Y is the number of compounding periods per year in the same transaction.

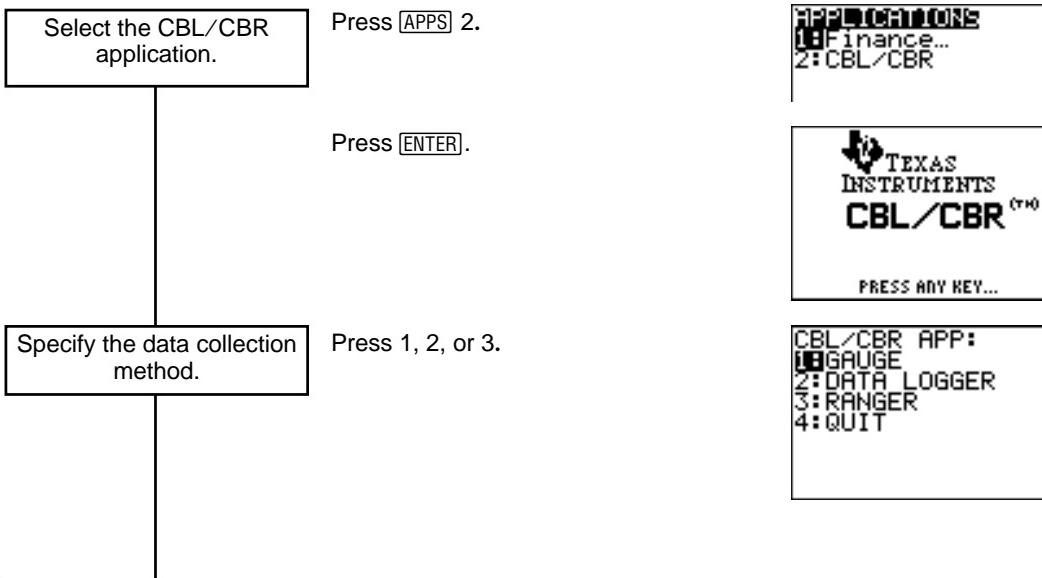
When you store a value to **P/Y**, the value for **C/Y** automatically changes to the same value. To store a unique value to **C/Y**, you must store the value to **C/Y** after you have stored a value to **P/Y**.

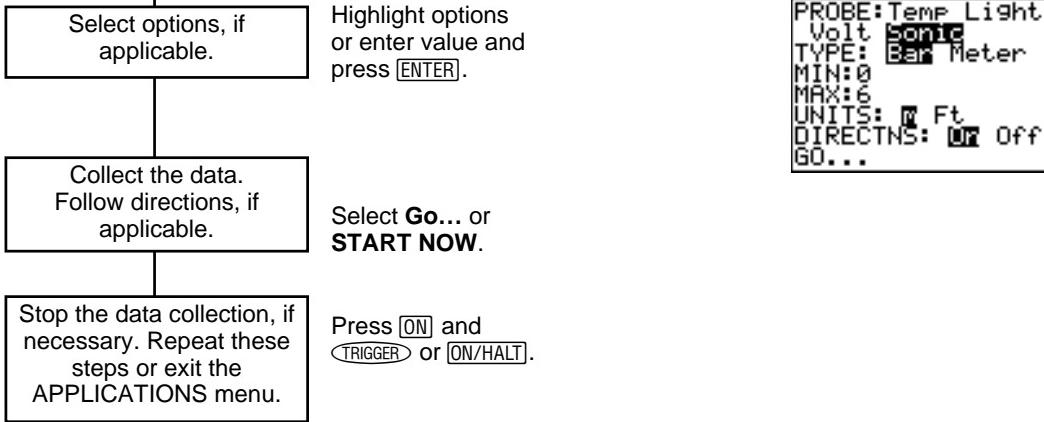
The CBL/CBR Application

The **CBL/CBR** application allows you to collect real world data. The TI-83 Plus comes with the **CBL/CBR** application already listed on the **APPLICATIONS** menu (**[APPS] 2**).

Steps for Running the CBL/CBR Application

Follow these basic steps when using the **CBL/CBR** application. You may not have to do all of them each time.





Selecting the CBL/CBR Application

To use a **CBL/CBR** application, you need a **CBL 2/CBL** or **CBR** (as applicable), a **TI-83 Plus**, and a unit-to-unit link cable.

1. Press **[APPS]**.



2. Select **2:CBL/CBR** to set up the **TI-83 Plus** to use either of the applications. An informational screen appears first.



3. Press any key to continue to the next menu.



Data Collection Methods and Options

Specifying the Data Collection Method from the CBL/CBR APP Menu

With a **CBL 2/CBL** or **CBR**, you can collect data in one of three ways: **GAUGE** (bar or meter), **DATA LOGGER** (a Temp-Time, Light-Time, Volt-Time, or Sonic-Time graph), or **RANGER**, which runs the **RANGER** program, the built-in **CBR** data collection program.

The **CBL/CBR APP** menu contains the following data collection methods:

CBL/CBR APP :

- 1: GAUGE Displays results as either a bar or meter.
 - 2: DATA LOGGER Displays results as a Temp-Time, Light-Time, Volt-Time, or Sonic-Time graph.
 - 3: RANGER Sets up and runs the **RANGER** program.
 - 4: QUIT Quits the CBL/CBR application.
-

Note: **CBL 2/CBL** and **CBR** differ in that **CBL 2/CBL** allows you to collect data using one of several different probes including: Temp (Temperature), Light, Volt (Voltage), or Sonic. **CBR** collects data using only the built-in Sonic probe. You can find more information on **CBL 2/CBL** and **CBR** in their user manuals.

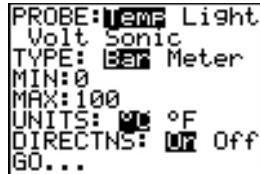
Specifying Options for Each Data Collection Method

After you select a data collection method from the **CBL/CBR APP** menu, a screen showing the options for that method is displayed. The method you choose, as well as the data collection options you choose for that method, determine whether you use the **CBR** or the **CBL 2/CBL**. Refer to the charts in the following sections to find the options for the application you are using.

GAUGE

The **GAUGE** data collection method lets you choose one of four different probes: temp, Light, Volt, or Sonic.

1. Press **APPS** 2 **ENTER**.
2. Select 1:**GAUGE**.
3. Select options.

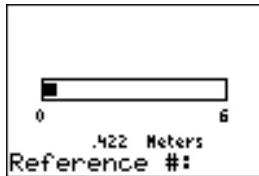
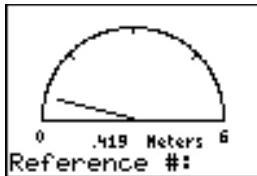


When you select a probe option, all other options change accordingly. Use **◀** and **▶** to move between the probe options. To select a probe, highlight the one you want with the cursor keys, and then press **ENTER**.

| GAUGE Options (Defaults) | | | | |
|--------------------------|--------------|--------------------|------|---------|
| Probe: | Temp | Light | Volt | Sonic |
| Type: | Bar or Meter | | | |
| Min: | 0 | 0 | -10 | 0 |
| Max: | 100 | 1 | 10 | 6 |
| Units: | °C or °F | mW/cm ² | Volt | m or Ft |
| Directions: | On or Off | | | |

TYPE

The **GAUGE** data collection results are represented according to **TYPE: Bar** or **Meter**. Highlight the one you want with the cursor keys, and then press **ENTER**.

Bar**Meter**

MIN and MAX

MIN and **MAX** refer to the minimum and maximum **UNIT** values for the specified probe. Defaults are listed in the Gauge Options table. See the CBL 2/CBL and CBR guidebook for specific **MIN/MAX** ranges. Enter values using the number keys.

UNITS

The results are displayed according to the **UNITS** specified. To specify a unit measurement (**Temp** or **Sonic** probes only), highlight the one you want using the cursor keys, enter a value using the number keys, and then press **[ENTER]**.

DIRECTNS (Directions)

If **DIRECTNS=On**, the calculator displays step-by-step directions on the screen, which help you set up and run the data collection. To select **On** or **Off**, highlight the one you want with the cursor keys, and then press **[ENTER]**.

With the **Sonic** data collection probe, if **DIRECTNS=On**, the calculator displays a menu screen before starting the application asking you to select **1:CBL** or **2:CBR**. This ensures that you get the appropriate directions. Press **1** to specify **CBL** or **2** to specify **CBR**.

Data Collection Comments and Results

To label a specific data point, press **[ENTER]** to pause the data collection. You will see a **Reference#:** prompt. Enter a number using the number keys. The calculator automatically converts the reference numbers and the corresponding results into list elements using the following list names (you cannot rename these lists):

| Probe | Comment Labels (<i>X</i>) Stored to: | Data Results (<i>Y</i>) Stored to: |
|-------|--|--------------------------------------|
| Temp | LTEMP | LTEMP |
| Light | LLIGHT | LLIGHT |
| Volt | LVOLT | LVOLT |
| Sonic | LDIST | LDIST |

To see all elements in one of these lists, you can insert these lists into the List editor just as you would any other list. Access list names from the **[2nd] [LIST]** NAMES menu.

Note: These lists are only temporary placeholders for comment labels and data results for any particular probe. Therefore, every time you collect data and enter comments for one of the four probes, the two lists pertaining to that probe are overwritten with comment labels and data results from the most recently collected data..

If you want to save comment labels and data results from more than one data collection, copy all list elements that you want to save to a list with a different name.

Also, the **DATA LOGGER** data collection method stores data results to the same list names, overwriting previously-collected data results, even those collected using the **GAUGE** data collection method.

DATA LOGGER

1. Press **APPS** 2 **ENTER**.

```
CBL/CBR APP:  
1:GAUGE  
2:DATA LOGGER  
3:RANGER  
4:QUIT
```

2. Select **2:DATA LOGGER**.

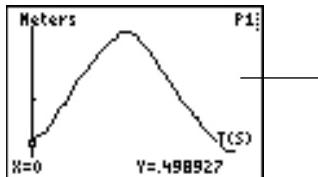
```
PROBE:Temp Light  
Volt Sonic  
#SAMPLES:99  
INTRVL(SEC):1  
UNITS: °C °F  
PLOT:Realtime End  
DIRECTIONS: On Off  
GO...
```

The **DATA LOGGER** data collection method lets you choose one of four different probes: **Temp**, **Light**, **Volt**, or **Sonic**. You can use the **CBL** 2/**CBL** with all probes; you can use the **CBR** only with the **Sonic** probe.

When you select a probe option, all other options change accordingly. Use **▶** and **◀** to move between the probe options. To select a probe, highlight the one you want with the cursor keys, and then press **ENTER**.

| DATA LOGGER Options (Defaults) | | | | |
|--------------------------------|----------------|--------------------|------|----------|
| | Temp | Light | Volt | Sonic |
| #SAMPLES: | 99 | 99 | 99 | 99 |
| INTRVL (SEC): | 1 | 1 | 1 | 1 |
| UNITS: | °C or °F | mW/cm ² | Volt | Cm or Ft |
| PLOT: | RealTme or End | | | |
| DIRECTNS: | On or Off | | | |
| Ymin (WINDOW): | 0 | 0 | -10 | 0 |
| Ymax (WINDOW): | 100 | 1 | 10 | 6 |

The **DATA LOGGER** data collection results are represented as a Temp-Time, Light-Time, Volt-Time, or Distance-Time graph.



A Distance-Time graph in meters (**Sonic** probe).

#SAMPLES

#SAMPLES refers to how many data samples are collected and then graphed. For example, if **#SAMPLES=99**, data collection stops after the 99th sample is collected. Enter values using the number keys.

INTRVL (SEC)

INTRVL (SEC) specifies the interval in seconds between each data sample that is collected. For example, if you want to collect 99 samples and **INTRVL=1**, it takes 99 seconds to finish data collection. Enter values using the number keys. See the **CBL 2/CBL** or **CBR** guidebook for more information about interval limits.

UNITS

The results are displayed according to the **UNITS** specified. To specify a unit measurement (**Temp** or **Sonic** only), highlight the one you want using the cursor keys, and then press **[ENTER]**.

PLOT

You can specify whether you want the calculator to collect realtime (**RealTme**) samples, which means that the calculator graphs data points immediately as they are being collected, or you can wait and show the graph only after all data points have been collected (**End**). Highlight the option you want with the cursor keys, and then press **ENTER**.

Ymin and Ymax

To specify **Ymin** and **Ymax** values for the final graph, press **WINDOW** to view the **PLOT WINDOW** screen. Use **▲** and **▼** to move between options. Enter **Ymin** and **Ymax** using the number keys. Press **2nd [QUIT]** to return to the **DATA LOGGER** options screen.

DIRECTNS (Directions)

If **DIRECTNS=On**, the calculator displays step-by-step directions on the screen, which help you set up and run the data collection. To select **On** or **Off**, highlight the one you want with the cursor keys, and then press **ENTER**.

With the **Sonic** data collection probe, if **DIRECTNS=On**, the calculator displays a menu screen before starting the application asking you to select **1:CBL** or **2:CBR**. This ensures that you get the appropriate directions. Press **1** to specify **CBL** or **2** to specify **CBR**.

Data Collection Results

The calculator automatically converts all collected data points into list elements using the following list names (you cannot rename the lists):

| Probe | Time Values (X) stored to: | Data Results (Y) Stored to: |
|-------|--------------------------------|---------------------------------|
| Temp | LTTEMP | LTEMP |
| Light | LTLGHT | LLIGHT |
| Volt | LTVOLT | LVOLT |
| Sonic | LTDIST | LDIST |

To see all elements in one of these lists, you can insert these lists into the List editor just as you would any other list. Access list names from the **[2nd] [LIST]** NAMES menu.

Note: These lists are only temporary placeholders for data results for any particular probe. Therefore, every time you collect data for one of the four probes, the list pertaining to that probe is overwritten with data results from the most recently collected data.

If you want to save data results from more than one data collection, copy all list elements that you want to save to a list with a different name.

Also, the **GAUGE** data collection method stores data results to the same list names, overwriting previously-collected data results, even those collected using the **DATA LOGGER** data collection method.

RANGER

Selecting the **RANGER** data collection method runs the CBR **RANGER** program, a customized program especially for the TI-83 Plus that makes it compatible with the CBR. When the collection process is halted, the **CBR RANGER** is deleted from RAM. To run the **CBR RANGER** program again, press **APPS** and select the **CBL/CBR** application.

Note: The Ranger data collection method only uses the Sonic probe.

1. Press **APPS** **2** **[ENTER]**.

CBL/CBR APP:
1: GAUGE
2: DATA LOGGER
3: RANGER
4: QUIT

2. Select **3:RANGER**.

3. Press **[ENTER]**.

TEXAS INSTRUMENTS

RANGER (V1.00)

PRESS [ENTER]

4. Select options.

MAIN MENU
1: SETUP/SAMPLE
2: SET DEFAULTS
3: APPLICATIONS
4: PLOT MENU
5: TOOLS
6: QUIT

For detailed information about the **RANGER** program as well as option explanations, see the [Getting Started with CBR](#) guidebook.

Starting Data Collection

Collecting the Data

After you specify all of the options for your data collection method, select the **Go** option from the **GAUGE** or **DATA LOGGER** options screen. If you are using the **RANGER** data collection method, select **1:SETUP/SAMPLE** from the **MAIN** menu, and then **START NOW**.

- If **DIRECTNS=Off**, **GAUGE** and **DATA LOGGER** data collection begin immediately.
- If **DIRECTNS=On**, the calculator displays step-by-step directions.

If **PROBE=Sonic**, the calculator first displays a menu screen asking you to select **1:CBL** or **2:CBR**. This ensures that you get the appropriate directions. Press **1** to specify **CBL 2/CBL** or **2** to specify **CBR**.

If you select **START NOW** from the **MAIN** menu of the **RANGER** data collection method, the calculator displays one directions screen. Press **ENTER** to begin data collection.

Stopping Data Collection

To stop the **GAUGE** data collection method, press **CLEAR** on the TI-83 Plus.

The **DATA LOGGER** and **RANGER** data collection methods stop after the specified number of samples have been collected. To stop them before this happens:

1. Press **ON** on the TI-83 Plus.
2. Press **TRIGGER** on the CBR, **START/STOP** on the CBL 2, or **ON/HALT** on the CBL.

To exit from the **GAUGE** or **DATA LOGGER** option menus without beginning data collection, press **2nd [QUIT]**.

To exit from the **RANGER** option menu without beginning data collection, select **MAIN** menu. Select **6:QUIT** to return to the **CBL/CBR APP** menu.

Press **4:QUIT** from the **CBL/CBR APP** menu to return to the TI-83 Plus Home screen.

Chapter 15: **CATALOG, Strings, Hyperbolic** **Functions**

Browsing the TI-83 Plus CATALOG

What Is the CATALOG?

The **CATALOG** is an alphabetical list of all functions and instructions on the TI-83 Plus. You also can access each **CATALOG** item from a menu or the keyboard, except:

- The six string functions
- The six hyperbolic functions
- The **solve(** instruction without the equation solver editor (Chapter 2)
- The inferential stat functions without the inferential stat editors (Chapter 13)

Note: The only **CATALOG** programming commands you can execute from the home screen are **GetCalc(**, **Get(**, and **Send(**.

Selecting an Item from the CATALOG

To select a CATALOG item, follow these steps.

1. Press **[2nd]** [CATALOG] to display the CATALOG.



The ► in the first column is the selection cursor.

2. Press **▼** or **▲** to scroll the CATALOG until the selection cursor points to the item you want.
 - To jump to the first item beginning with a particular letter, press that letter; alpha-lock is on.
 - Items that begin with a number are in alphabetical order according to the first letter after the number. For example, **2-PropZTest** is among the items that begin with the letter **P**.
 - Functions that appear as symbols, such as **+**, **-1**, **<**, and **√(**, follow the last item that begins with **Z**. To jump to the first symbol, **!**, press **[θ]**.

3. Press **[ENTER]** to paste the item to the current screen.

```
abs([■])
```

Tip: From the top of the **CATALOG** menu, press **[▲]** to move to the bottom. From the bottom, press **[▼]** to move to the top.

Entering and Using Strings

What Is a String?

A string is a sequence of characters that you enclose within quotation marks. On the TI-83 Plus, a string has two primary applications.

- It defines text to be displayed in a program.
- It accepts input from the keyboard in a program.

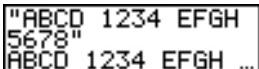
Characters are the units that you combine to form a string.

- Count each number, letter, and space as one character.
- Count each instruction or function name, such as **sin(** or **cos(**, as one character; the TI-83 Plus interprets each instruction or function name as one character.

Entering a String

To enter a string on a blank line on the home screen or in a program, follow these steps.

1. Press **ALPHA** [**"**] to indicate the beginning of the string.
2. Enter the characters that comprise the string.

- Use any combination of numbers, letters, function names, or instruction names to create the string.
 - To enter a blank space, press **[ALPHA] [.]**.
 - To enter several alpha characters in a row, press **[2nd] [A-LOCK]** to activate alpha-lock.
3. Press **[ALPHA] ["]** to indicate the end of the string.
"string"
4. Press **[ENTER]**. On the home screen, the string is displayed on the next line without quotations. An ellipsis (...) indicates that the string continues beyond the screen. To scroll the entire string, press **[▶]** and **[◀]**.
- 
- The handheld screen displays the string "ABCD 1234 EFGH" on the first line and "5678" on the second line. A vertical ellipsis (...) is shown on the third line, indicating the string continues. The handheld has a black frame and a white keypad.
- Note:** Quotation marks do not count as string characters.

Storing Strings to String Variables

String Variables

The TI-83 Plus has 10 variables to which you can store strings. You can use string variables with string functions and instructions.

To display the **VARS STRING** menu, follow these steps.

1. Press **[VARS]** to display the **VARS** menu. Move the cursor to **7:String**.



2. Press **[ENTER]** to display the **STRING** secondary menu.



Storing a String to a String Variable

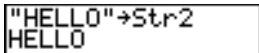
To store a string to a string variable, follow these steps.

1. Press **[ALPHA] ["]**, enter the string, and press **[ALPHA] ["]**.
2. Press **[STO►]**.
3. Press **[VARS] 7** to display the **VARS STRING** menu.
4. Select the string variable (from **Str1** to **Str9**, or **Str0**) to which you want to store the string.



The string variable is pasted to the current cursor location, next to the store symbol (\rightarrow).

5. Press **[ENTER]** to store the string to the string variable. On the home screen, the stored string is displayed on the next line without quotation marks.



Displaying the Contents of a String Variable

To display the contents of a string variable on the home screen, select the string variable from the **VARS STRING** menu, and then press **ENTER**. The string is displayed.

Str2
HELLO

String Functions and Instructions in the CATALOG

Displaying String Functions and Instructions in the CATALOG

String functions and instructions are available only from the **CATALOG**. The table below lists the string functions and instructions in the order in which they appear among the other **CATALOG** menu items. The ellipses in the table indicate the presence of additional **CATALOG** items.

CATALOG

| | |
|-------------|--------------------------------------|
| ... | |
| Equ►String(| Converts an equation to a string. |
| expr(| Converts a string to an expression. |
| ... | |
| inString(| Returns a character's place number. |
| ... | |
| length(| Returns a string's character length. |
| ... | |
| String►Equ(| Converts a string to an equation. |
| sub(| Returns a string subset as a string. |
| ... | |

+ (Concatenation)

To concatenate two or more strings, follow these steps.

1. Enter $string1$, which can be a string or string name.
2. Press $\boxed{+}$.
3. Enter $string2$, which can be a string or string name. If necessary, press $\boxed{+}$ and enter $string3$, and so on.
 $string1 + string2 + string3 \dots$
4. Press $\boxed{\text{ENTER}}$ to display the strings as a single string.

```
"HIJK" →Str1:Str  
1+"LMNOP"  
HIJK LMNOP
```

Selecting a String Function from the CATALOG

To select a string function or instruction and paste it to the current screen, follow the steps for selecting an item from the [CATALOG](#).

Equ▶String(

Equ▶String(converts to a string an equation that is stored to any VARS Y-VARS variable. **Yn** contains the equation. **Strn** (from **Str1** to **Str9**, or **Str0**) is the string variable to which you want the equation to be stored as a string.

Equ▶String(Yn,Strn)

```
"3X"→Y1      Done  
Equ▶String(Y1,Str1)  
Str1          Done  
3X
```

expr(

expr(converts the character string contained in *string* to an expression and executes it. *string* can be a string or a string variable.

expr(*string*)

| | |
|----------------|----|
| 2→X: "5X"→Str1 | |
| 5X | |
| expr(Str1)→A | 10 |
| A | 10 |

| | |
|-----------------|---|
| expr("1+2+X^2") | 7 |
|-----------------|---|

inString(

inString(returns the character position in *string* of the first character of *substring*. *string* can be a string or a string variable. *start* is an optional character position at which to start the search; the default is 1.

inString(string,substring[,start])

```
inString("PQRSTU  
V","STU")  
        4  
inString("ABCABC  
","ABC",4)  
        4
```

Note: If *string* does not contain *substring*, or *start* is greater than the length of *string*, **inString(** returns **0**.

length(

length(returns the number of characters in *string*. *string* can be a string or string variable.

Note: An instruction or function name, such as **sin(** or **cos(**, counts as one character.

length(string)

```
"WXYZ"→Str1  
WXYZ  
length(Str1)      4
```

String►Equ(

String►Equ(converts *string* into an equation and stores the equation to Y_n . *string* can be a string or string variable. **String►Equ(** is the inverse of **Equ►String(**.

String►Equ(*string*, Y_n)

```
"2X"→Str2
2X
String►Equ(Str2,
Y2)
Done
```



```
Plot1 Plot2 Plot3
\Y1=
\Y2 2X
```

sub(

sub(returns a string that is a subset of an existing *string*. *string* can be a string or a string variable. *begin* is the position number of the first character of the subset. *length* is the number of characters in the subset.

sub(*string*,*begin*,*length*)

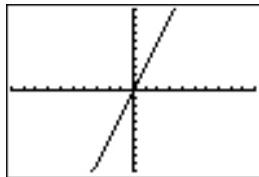
```
"ABCDEFG"→Str5
ABCDEFG
sub(Str5,4,2)
DE
```

Entering a Function to Graph during Program Execution

In a program, you can enter a function to graph during program execution using these commands.

```
PROGRAM: INPUT  
:Input "ENTRY=",  
Str3  
:String>Eau(Str3  
,Y3)  
:DispGraph
```

```
prgmINPUT  
ENTRY=3X■
```



Note: When you execute this program, enter a function to store to Y_3 at the $\text{ENTRY}=$ prompt.

Hyperbolic Functions in the CATALOG

Hyperbolic Functions

The hyperbolic functions are available only from the **CATALOG**. The table below lists the hyperbolic functions in the order in which they appear among the other **CATALOG** menu items. The ellipses in the table indicate the presence of additional **CATALOG** items.

CATALOG

...

$\cosh()$ Hyperbolic cosine

$\cosh^{-1}()$ Hyperbolic arccosine

...

$\sinh()$ Hyperbolic sine

$\sinh^{-1}()$ Hyperbolic arcsine

...

$\tanh()$ Hyperbolic tangent

$\tanh^{-1}()$ Hyperbolic arctangent

...

sinh(, cosh(, tanh(

sinh(, **cosh(**, and **tanh(** are the hyperbolic functions. Each is valid for real numbers, expressions, and lists.

sinh(value)

cosh(value)

tanh(value)

```
sinh(.5)
.5210953055
cosh(.25,.5,13)
{1.0314131 1.12...
```

sinh⁻¹(, cosh⁻¹(, tanh⁻¹(

sinh⁻¹(is the hyperbolic arcsine function. **cosh⁻¹(** is the hyperbolic arccosine function. **tanh⁻¹(** is the hyperbolic arctangent function. Each is valid for real numbers, expressions, and lists.

sinh⁻¹(value)

cosh⁻¹(value)

sinh⁻¹(value)

```
sinh-1(0,1)
{0 .881373587
tanh-1(-.5)
-.5493061443
```

Chapter 16: Programming

Getting Started: Volume of a Cylinder

Getting Started is a fast-paced introduction. Read the chapter for details.

A program is a set of commands that the TI-83 Plus executes sequentially, as if you had entered them from the keyboard. Create a program that prompts for the radius R and the height H of a cylinder and then computes its volume.

1. Press **PRGM** **▶** **▶** to display the **PRGM NEW** menu.



2. Press **ENTER** to select 1:Create New. The **Name=** prompt is displayed, and alpha-lock is on. Press **[C]** **[Y]** **[L]** **[I]** **[N]** **[D]** **[E]** **[R]**, and then press **ENTER** to name the program **CYLINDER**.



You are now in the program editor. The colon (:) in the first column of the second line indicates the beginning of a command line.

3. Press **PRGM** ▶ 2 to select 2:**Prompt** from the **PRGM I/O** menu. **Prompt** is copied to the command line. Press **ALPHA** [R] [,] **ALPHA** [H] to enter the variable names for radius and height. Press **ENTER**.

```
PROGRAM:CYLINDER
:Prompt R,H
:■
```

4. Press **2nd** [π] **ALPHA** [R] [x^2] **ALPHA** [H] **STO** ▶ **ALPHA** [V] **ENTER** to enter the expression $\pi R^2 H$ and store it to the variable **V**.

```
PROGRAM:CYLINDER
:Prompt R,H
:πR²H→V
:■
```

5. Press **PRGM** ▶ 3 to select 3:**Disp** from the **PRGM** I/O menu. **Disp** is pasted to the command line. Press **2nd** [A-LOCK] ["] [V] [O] [L] [U] [M] [E][_] [I] [S] ["] **ALPHA** [,] **ALPHA** [V] **ENTER** to set up the program to display the text **VOLUME IS** on one line and the calculated value of **V** on the next.

```
PROGRAM:CYLINDER
:Prompt R,H
:πR²H→V
:Disp "VOLUME IS
",V
:■
```

6. Press **2nd** [QUIT] to display the home screen.
7. Press **PRGM** to display the **PRGM EXEC** menu. The items on this menu are the names of stored programs.

```
EXEC EDIT NEW
1:CYLINDER
```

8. Press **[ENTER]** to paste **prgmCYLINDER** to the current cursor location. (If **CYLINDER** is not item 1 on your **PRGM EXEC** menu, move the cursor to **CYLINDER** before you press **[ENTER]**.)

```
prgmCYLINDER■
```

9. Press **[ENTER]** to execute the program. Enter 1.5 for the radius, and then press **[ENTER]**. Enter 3 for the height, and then press **[ENTER]**. The text **VOLUME IS**, the value of **V**, and **Done** are displayed.

```
prgmCYLINDER
R=1.5
H=3
VOLUME IS
      21.20575041
      Done
```

Repeat steps 7 through 9 and enter different values for **R** and **H**.

Creating and Deleting Programs

What Is a Program?

A program is a set of one or more command lines. Each line contains one or more instructions. When you execute a program, the TI-83 Plus performs each instruction on each command line in the same order in which you entered them. The number and size of programs that the TI-83 Plus can store is limited only by available memory.

Creating a New Program

To create a new program, follow these steps.

1. Press **PRGM** **◀** to display the **PRGM NEW** menu.



2. Press **ENTER** to select **1:Create New**. The **Name=** prompt is displayed, and alpha-lock is on.
3. Press a letter from A to Z or Ø to enter the first character of the new program name.

Note: A program name can be one to eight characters long. The first character must be a letter from A to Z or Ø. The second through eighth characters can be letters, numbers, or Ø.

4. Enter zero to seven letters, numbers, or θ to complete the new program name.
5. Press **[ENTER]**. The program editor is displayed.
6. Enter one or more program commands.
7. Press **[2nd] [QUIT]** to leave the program editor and return to the home screen.

Managing Memory and Deleting a Program

To check whether adequate memory is available for a program you want to enter:

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.
2. Select **2:Mem Mgmt/Del** to display the **MEMORY MANAGEMENT/DELETE** menu (Chapter 18).
3. Select **7:Prgm** to display the PRGM editor.

| | |
|------------|--------|
| RAM FREE | 19635 |
| ARC FREE | 847598 |
| *PROGRAM1 | 3475 |
| ► PROGRAM2 | 2844 |

The TI-83 Plus expresses memory quantities in bytes.

You can increase available memory in one of two ways. You can delete one or more programs or you can archive some programs.

To increase available memory by deleting a specific program:

1. Press **[2nd] [MEM]** and then select **2:Mem Mgmt/Del** from the **MEMORY** menu.



2. Select **7:Prgm** to display the PRGM editor (Chapter 18).

| | |
|------------|--------|
| RAM FREE | 19635 |
| ARC FREE | 847598 |
| *PROGRAM1 | 3475 |
| ► PROGRAM2 | 2844 |

3. Press **▲** and **▼** to move the selection cursor (**►**) next to the program you want to delete, and then press **[DEL]**. The program is deleted from memory.

Note: You will receive a message asking you to confirm this delete action. Select **2:yes** to continue.

To leave the PRGM editor screen without deleting anything, press **[2nd] [QUIT]**, which displays the home screen.

To increase available memory by archiving a program:

1. Press **[2nd] [MEM]** and then select **2:Mem Mgmt/Del** from the **MEMORY** menu.
2. Select **2:Mem Mgmt/Del** to display the **MEM MGMT/DEL** menu.
3. Select **7:Prgm...** to display the **PRGM** menu.

| | |
|------------|--------|
| RAM FREE | 22464 |
| ARC FREE | 844751 |
| *PROGRAM1 | 3475 |
| ►*PROGRAM2 | 2844 |

4. Press **[ENTER]** to archive the program. An asterisk will appear to the left of the program to indicate it is an archived program.

To unarchive a program in this screen, put the cursor next to the archived program and press **[ENTER]**. The asterisk will disappear.

Note: Archive programs cannot be edited or executed. In order to edit or execute an archived program, you must first unarchive it.

Entering Command Lines and Executing Programs

Entering a Program Command Line

You can enter on a command line any instruction or expression that you could execute from the home screen. In the program editor, each new command line begins with a colon. To enter more than one instruction or expression on a single command line, separate each with a colon.

Note: A command line can be longer than the screen is wide; long command lines wrap to the next screen line.

While in the program editor, you can display and select from menus. You can return to the program editor from a menu in either of two ways.

- Select a menu item, which pastes the item to the current command line.
- Press **CLEAR**.

When you complete a command line, press **ENTER**. The cursor moves to the next command line.

Programs can access variables, lists, matrices, and strings saved in memory. If a program stores a new value to a variable, list, matrix, or string, the program changes the value in memory during execution.

You can call another program as a subroutine.

Executing a Program

To execute a program, begin on a blank line on the home screen and follow these steps.

1. Press **[PRGM]** to display the **PRGM EXEC** menu.
2. Select a program name from the **PRGM EXEC** menu. **prgmlink** is pasted to the home screen (for example, **prgmCYLINDER**).
3. Press **[ENTER]** to execute the program. While the program is executing, the busy indicator is on.

Last Answer (**Ans**) is updated during program execution. Last Entry is not updated as each command is executed (Chapter 1).

The TI-83 Plus checks for errors during program execution. It does not check for errors as you enter a program.

Breaking a Program

To stop program execution, press **ON**. The **ERR:BREAK** menu is displayed.

- To return to the home screen, select **1:Quit**.
- To go where the interruption occurred, select **2:Goto**.

Editing Programs

Editing a Program

To edit a stored program, follow these steps.

1. Press **PRGM** ▶ to display the **PRGM EDIT** menu.
2. Select a program name from the **PRGM EDIT** menu. Up to the first seven lines of the program are displayed.
Note: The program editor does not display a ↓ to indicate that a program continues beyond the screen.
3. Edit the program command lines.
 - Move the cursor to the appropriate location, and then delete, overwrite, or insert.
 - Press **CLEAR** to clear all program commands on the command line (the leading colon remains), and then enter a new program command.

Tip: To move the cursor to the beginning of a command line, press **2nd** ▲; to move to the end, press **2nd** ▶. To scroll the cursor down seven command lines, press **ALPHA** ▾. To scroll the cursor up seven command lines, press **ALPHA** ▴.

Inserting and Deleting Command Lines

To insert a new command line anywhere in the program, place the cursor where you want the new line, press **[2nd] [INS]**, and then press **[ENTER]**. A colon indicates a new line.

To delete a command line, place the cursor on the line, press **[CLEAR]** to clear all instructions and expressions on the line, and then press **[DEL]** to delete the command line, including the colon.

Copying and Renaming Programs

Copying and Renaming a Program

To copy all command lines from one program into a new program, follow steps 1 through 5 for [Creating a New Program](#), and then follow these steps.

1. Press **[2nd] [RCL]**. **Rcl** is displayed on the bottom line of the program editor in the new program (Chapter 1).
2. Press **[PRGM] [◀]** to display the **PRGM EXEC** menu.
3. Select a name from the menu. **prgmname** is pasted to the bottom line of the program editor.
4. Press **[ENTER]**. All command lines from the selected program are copied into the new program.

Copying programs has at least two convenient applications.

- You can create a template for groups of instructions that you use frequently.
- You can rename a program by copying its contents into a new program.

Note: You also can copy all the command lines from one existing program to another existing program using **RCL**.

Scrolling the PRGM EXEC and PRGM EDIT Menus

The TI-83 Plus sorts **PRGM EXEC** and **PRGM EDIT** menu items automatically into alphanumerical order. Each menu only labels the first 10 items using **1** through **9**, then **0**.

To jump to the first program name that begins with a particular alpha character or θ , press **[ALPHA]** [*letter from A to Z or θ*].

Tip: From the top of either the **PRGM EXEC** or **PRGM EDIT** menu, press **[▼]** to move to the bottom. From the bottom, press **[▲]** to move to the top. To scroll the cursor down the menu seven items, press **[ALPHA] [▼]**. To scroll the cursor up the menu seven items, press **[ALPHA] [▲]**.

PRGM CTL (Control) Instructions

PRGM CTL Menu

To display the PRGM CTL (program control) menu, press **PRGM** from the program editor only.

CTL I/O EXEC

| | |
|---------------|--|
| 1:If | Creates a conditional test. |
| 2:Then | Executes commands when If is true. |
| 3:Else | Executes commands when If is false. |
| 4:For(| Creates an incrementing loop. |
| 5:While | Creates a conditional loop. |
| 6:Repeat | Creates a conditional loop. |
| 7:End | Signifies the end of a block. |
| 8:Pause | Pauses program execution. |
| 9:Lbl | Defines a label. |
| 0:Goto | Goes to a label. |
| A:IS>(| Increments and skips if greater than. |
| B:DS<(| Decrements and skips if less than. |
| C:Menu(| Defines menu items and branches. |
| D:prgm | Executes a program as a subroutine. |
| E:Return | Returns from a subroutine. |
| F:Stop | Stops execution. |
| G:DelVar | Deletes a variable from within program. |
| H:GraphStyle(| Designates the graph style to be drawn. |

These menu items direct the flow of an executing program. They make it easy to repeat or skip a group of commands during program execution. When you select an item from the menu, the name is pasted to the cursor location on a command line in the program.

To return to the program editor without selecting an item, press **CLEAR**.

Controlling Program Flow

Program control instructions tell the TI-83 Plus which command to execute next in a program. **If**, **While**, and **Repeat** check a defined condition to determine which command to execute next. Conditions frequently use relational or Boolean tests (Chapter 2), as in:

If A<7:A+1→A

or

If N=1 and M=1:Goto Z

If

Use **If** for testing and branching. If *condition* is false (zero), then the *command* immediately following **If** is skipped. If *condition* is true (nonzero), then the next *command* is executed. **If** instructions can be nested.

```
:If condition  
:command (if true)  
:command
```

Program

```
PROGRAM:COUNT  
:0→A  
:Lbl Z  
:A+1→A  
:Disp "A IS",A  
:If A≥2  
:Stop  
:Goto Z
```

Output

```
PrgmCOUNT  
A IS  
A IS  
1  
2  
Done
```

If-Then

Then following an If executes a group of *commands* if *condition* is true (nonzero). End identifies the end of the group of *commands*.

```
:If condition  
:Then  
:command (if true)  
:command (if true)  
:End  
:command
```

Program

```
PROGRAM:TEST  
:1→X:10→Y  
:If X<10  
:Then  
:2X+3→X  
:2Y-3→Y  
:End  
:Disp X,Y
```

Output

```
PrgrmTEST  
5  
17  
Done
```

If-Then-Else

Else following **If-Then** executes a group of *commands* if *condition* is false (zero). **End** identifies the end of the group of *commands*.

```
:If condition  
:Then  
:command (if true)  
:command (if true)  
:Else  
:command (if false)  
:command (if false)  
:End  
:command
```

Program

```
PROGRAM:TESTELSE
:Input "X=",X
:If X<0
:Then
:X>Y
:Else
:X>Y
:End
```

```
:Disp (X,Y)
```

Output

```
prgmTESTELSE
X=5
      (5,5)
Done
X=-5
(-5,25)
Done
```

For(

For(loops and increments. It increments *variable* from *begin* to *end* by *increment*. *increment* is optional (default is 1) and can be negative (*end*<*begin*). *end* is a maximum or minimum value not to be exceeded. **End** identifies the end of the loop. **For(** loops can be nested.

```
:For(variable,begin,end[,increment])
:command (while end not exceeded)
:command (while end not exceeded)
:End
:command
```

Program

```
PROGRAM:SQUARE  
:For(A,0,8,2)  
:Disp A2  
:End
```

Output

```
Pr9mSQUARE  
0  
4  
16  
36  
64  
Done
```

While

While performs a group of *commands* while *condition* is true. *condition* is frequently a relational test (Chapter 2). *condition* is tested when **While** is encountered. If *condition* is true (nonzero), the program executes a group of *commands*. **End** signifies the end of the group. When *condition* is false (zero), the program executes each *command* following **End**. **While** instructions can be nested.

:While *condition*

:command (**while** *condition* is true)

:command (**while** *condition* is true)

:End

:command

Program

```
PROGRAM:LOOP  
:0→I  
:0→J  
:While I<6  
:J+1→J  
:I+1→I  
:End  
:Disp "J=",J
```

Output

```
PrgrmLOOP  
J= 6  
Done
```

Repeat

Repeat repeats a group of *commands* until *condition* is true (nonzero). It is similar to **While**, but *condition* is tested when **End** is encountered; therefore, the group of *commands* is always executed at least once. **Repeat** instructions can be nested.

:Repeat *condition*

:command (until *condition* is true)

:command (until *condition* is true)

:End

:Command

Program

```
PROGRAM:RLOOP  
:0→I  
:0→J  
:Repeat I≥6  
:J+1→J  
:I+1→I  
:End  
:Disp "J=",J
```

Output

```
PrgrmRLOOP  
J= 6  
Done
```

End

End identifies the end of a group of *commands*. You must include an **End** instruction at the end of each **For**(, **While**, or **Repeat** loop. Also, you must paste an **End** instruction at the end of each **If-Then** group and each **If-Then-Else** group.

Pause

Pause suspends execution of the program so that you can see answers or graphs. During the pause, the pause indicator is on in the top-right corner. Press **[ENTER]** to resume execution.

- **Pause** without a *value* temporarily pauses the program. If the **DispGraph** or **Disp** instruction has been executed, the appropriate screen is displayed.
- **Pause** with *value* displays *value* on the current home screen. *value* can be scrolled.

Pause [*value*]

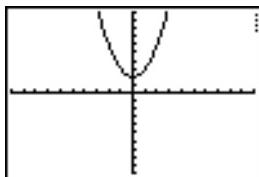
Program

```
PROGRAM:PAUSE  
::10→X  
::"X²+2"→Y₁  
::Disp "X=",X  
::Pause  
::DispGraph  
::Pause  
::Disp
```

Output

```
prgmPAUSE  
X=
```

10



```
prgmPAUSE  
X=
```

10
Done

Lbl, Goto

Lbl (label) and **Goto** (go to) are used together for branching.

Lbl specifies the *label* for a command. *label* can be one or two characters (A through Z, 0 through 99, or θ).

Lbl *label*

Goto causes the program to branch to *label* when **Goto** is encountered.

Goto *label*

Program

```
PROGRAM:CUBE
:Lbl 99
:Input A
:If A≥100
:Stop
:Disp A³
:Pause
:Goto 99
```

Output

```
PrgmCUBE
?2
?3
?105
Done
```

IS>(

IS>((increment and skip) adds 1 to *variable*. If the answer is $> value$ (which can be an expression), the next *command* is skipped; if the answer is $\leq value$, the next *command* is executed. *variable* cannot be a system variable.

:IS>(variable,value)

:command (if answer $\leq value$)

:command (if answer $> value$)

Program

```
PROGRAM: ISKIP
:7→A
:IS>(A,6)
:Disp "NOT > 6"
:Disp "> 6"
```

Output

```
PrgmISKIP
> 6
Done
```

Note: **IS>(** is not a looping instruction.

DS<(

DS<((decrement and skip) subtracts 1 from *variable*. If the answer is $< value$ (which can be an expression), the next *command* is skipped; if the answer is $\geq value$, the next *command* is executed. *variable* cannot be a system variable.

:DS<(variable,value)

:command (if answer $\geq value$)

:command (if answer $< value$)

Program

```
PROGRAM:DSKIP
:1→A
:DS<(A,6)
:Disp "> 6"
:Disp "NOT > 6"
```

Output

```
PrgmDSKIP
NOT > 6
Done
```

Note: DS< is not a looping instruction.

Menu(

Menu(sets up branching within a program. If **Menu(** is encountered during program execution, the menu screen is displayed with the specified menu items, the pause indicator is on, and execution pauses until you select a menu item.

The menu *title* is enclosed in quotation marks ("). Up to seven pairs of menu items follow. Each pair comprises a *text* item (also enclosed in quotation marks) to be displayed as a menu selection, and a *label* item to which to branch if you select the corresponding menu selection.

Menu("title","text1",label1,"text2",label2, . . .)

Program

```
PROGRAM: TOSSDICE  
:Menu("TOSS DICE"  
", "FAIR DICE", A,  
"WEIGHTED DICE",  
B)
```

Output



The program above pauses until you select **1** or **2**. If you select **2**, for example, the menu disappears and the program continues execution at **Lbl B**.

prgm

Use **prgm** to execute other programs as subroutines. When you select **prgm**, it is pasted to the cursor location. Enter characters to spell a program *name*. Using **prgm** is equivalent to selecting existing programs from the **PRGM EXEC** menu; however, it allows you to enter the name of a program that you have not yet created.

prgm*name*

Note: You cannot directly enter the subroutine name when using **RCL**. You must paste the name from the **PRGM EXEC** menu.

Return

Return quits the subroutine and returns execution to the calling program, even if encountered within nested loops. Any loops are ended. An implied **Return** exists at the end of any program that is called as a subroutine. Within the main program, **Return** stops execution and returns to the home screen.

Stop

Stop stops execution of a program and returns to the home screen. **Stop** is optional at the end of a program.

DelVar

DelVar deletes from memory the contents of *variable*.

DelVar *variable*

```
PROGRAM:DELMATR
:DelVar [A]■
```

GraphStyle(

GraphStyle(designates the style of the graph to be drawn. *function#* is the number of the **Y=** function name in the current graphing mode. *graphstyle* is a number from **1** to **7** that corresponds to the graph style, as shown below.

| | |
|----------------------------|------------------------|
| 1 = \ (line) | 5 = ↗ (path) |
| 2 = ↘ (thick) | 6 = ⓘ (animate) |
| 3 = ▲ (shade above) | 7 = · (dot) |
| 4 = ▼ (shade below) | |

GraphStyle(*function#,graphstyle*)

For example, **GraphStyle(1,5)** in **Func** mode sets the graph style for **Y1** to ↗ (path; 5).

Not all graph styles are available in all graphing modes. For a detailed description of each graph style, see the Graph Styles table in Chapter 3.

PRGM I/O (Input/Output) Instructions

PRGM I/O Menu

To display the PRGM I/O (program input/output) menu, press **PRGM ▶** from within the program editor only.

CTL I/O EXEC

| | |
|-------------|---|
| 1:Input | Enters a value or uses the cursor. |
| 2:Prompt | Prompts for entry of variable values. |
| 3:Disp | Displays text, value, or the home screen. |
| 4:DispGraph | Displays the current graph. |
| 5:DispTable | Displays the current table. |
| 6:Output(| Displays text at a specified position. |
| 7:getKey | Checks the keyboard for a keystroke. |
| 8:ClrHome | Clears the display. |
| 9:ClrTable | Clears the current table. |
| 0:GetCalc(| Gets a variable from another TI-83 Plus. |
| A:Get(| Gets a variable from CBL 2™/CBL™ or CBR™. |
| B:Send(| Sends a variable to CBL 2/CBL or CBR. |

These instructions control input to and output from a program during execution. They allow you to enter values and display answers during program execution.

To return to the program editor without selecting an item, press **CLEAR**.

Displaying a Graph with Input

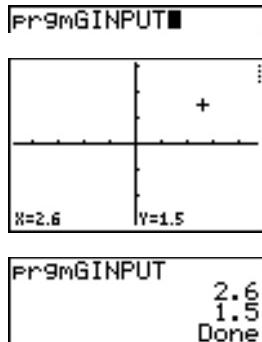
Input without a variable displays the current graph. You can move the free-moving cursor, which updates X and Y (and R and θ for PolarGC format). The pause indicator is on. Press **ENTER** to resume program execution.

Input

Program

```
PROGRAM:GINPUT
:FnOff
:2Decimal
:Input
:Disp X,Y
```

Output



Storing a Variable Value with Input

Input with *variable* displays a ? (question mark) prompt during execution. *variable* may be a real number, complex number, list, matrix, string, or **Y=** function. During program execution, enter a value, which can be an expression, and then press **[ENTER]**. The value is evaluated and stored to *variable*, and the program resumes execution.

Input [*variable*]

You can display *text* or the contents of **Strn** (a string variable) of up to 16 characters as a prompt. During program execution, enter a value after the prompt and then press **[ENTER]**. The value is stored to *variable*, and the program resumes execution.

Input ["*text*",*variable*]

Input [**Strn**,*variable*]

Program

```
PROGRAM:HINPUT
:Input A
:Input L1
:Input "Y1=",Y1
:Input "DATA=",L
DATA
:Disp Y1(A)
:Disp Y1(L1)
:Disp Y1(LDATA)
```

Output

```
PRGMHINPUT
?2
?(1,2,3)
Y1="2X+2"
DATA=(4,5,6)
6
(4,6,8)
(10,12,14)
Done
```

Note: When a program prompts for input of lists and **Yn** functions during execution, you must include the braces ({ }) around the list elements and quotation marks (") around the expressions.

Prompt

During program execution, **Prompt** displays each *variable*, one at a time, followed by =?. At each prompt, enter a value or expression for each *variable*, and then press **ENTER**. The values are stored, and the program resumes execution.

Prompt *variableA[,variableB,...,variable n]*

Program

```
PROGRAM:WINDOW
:Prompt Xmin
:Prompt Xmax
:Prompt Ymin
:Prompt Ymax
```

Output

```
Pr9mWINDOW
Xmin=?-10
Xmax=?10
Ymin=?-3
Ymax=?3
```

Done

Note: Y= functions are not valid with **Prompt**.

Displaying the Home Screen

Disp (display) without a value displays the home screen. To view the home screen during program execution, follow the **Disp** instruction with a **Pause** instruction.

Disp

Displaying Values and Messages

Disp with one or more *values* displays the value of each.

Disp [*valueA,valueB,valueC,...,value n*]

- If *value* is a variable, the current value is displayed.
- If *value* is an expression, it is evaluated and the result is displayed on the right side of the next line.
- If *value* is text within quotation marks, it is displayed on the left side of the current display line. → is not valid as text.

Program

```
PROGRAM:A  
:Disp "THE ANSWER IS ",π²/2
```

Output

```
PrgrmA  
THE ANSWER IS  
1.570796327  
Done
```

If **Pause** is encountered after **Disp**, the program halts temporarily so you can examine the screen. To resume execution, press **[ENTER]**.

Note: If a matrix or list is too large to display in its entirety, ellipses (...) are displayed in the last column, but the matrix or list cannot be scrolled. To scroll, use **Pause value**.

DispGraph

DispGraph (display graph) displays the current graph. If **Pause** is encountered after **DispGraph**, the program halts temporarily so you can examine the screen. Press **[ENTER]** to resume execution.

DispTable

DispTable (display table) displays the current table. The program halts temporarily so you can examine the screen. Press **[ENTER]** to resume execution.

Output(

Output(displays *text* or *value* on the current home screen beginning at *row* (1 through 8) and *column* (1 through 16), overwriting any existing characters.

Tip: You may want to precede **Output(** with **ClrHome**.

Expressions are evaluated and values are displayed according to the current mode settings. Matrices are displayed in entry format and wrap to the next line. → is not valid as text.

Output(*row*,*column*,"*text*")

Output(*row*,*column*,*value*)

Program

```
PROGRAM:OUTPUT  
:3+5→B  
:ClrHome  
:Output(5,4,"ANS  
WER:"  
:Output(5,12,B)
```

Output

```
ANSWER: 8
```

For **Output(** on a **Horiz** split screen, the maximum value for *row* is 4.

getKey

getKey returns a number corresponding to the last key pressed, according to the key code diagram below. If no key has been pressed, **getKey** returns 0. Use **getKey** inside loops to transfer control, for example, when creating video games.

Program

```
PROGRAM:GETKEY  
:While 1  
:getKey→K  
:While K=0  
:getKey→K  
:End  
:Disp K  
:If K=105
```

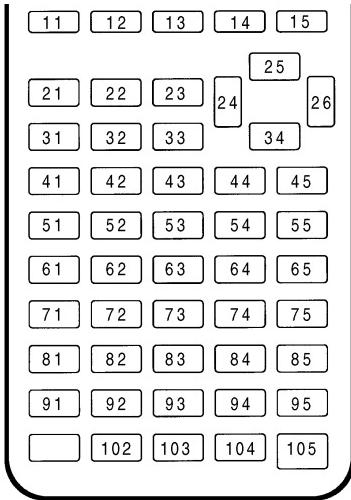
Output

```
PrgmGETKEY  
41  
42  
43  
105  
Done
```

Note: **MATH**, **APPS**, **PRGM**, and **ENTER** were pressed during program execution.

Note: You can press **ON** at any time during execution to break the program.

TI-83 Plus Key Code Diagram



ClrHome, ClrTable

ClrHome (clear home screen) clears the home screen during program execution.

ClrTable (clear table) clears the values in the table during program execution.

GetCalc(

GetCalc(gets the contents of *variable* on another TI-83 Plus and stores it to *variable* on the receiving TI-83 Plus. *variable* can be a real or complex number, list element, list name, matrix element, matrix name, string, **Y=** variable, graph database, or picture.

GetCalc(variable)

Note: **GetCalc(** does not work between TI-82 and TI-83 Plus calculators.

Get(, Send(

Get(gets data from the CBL 2/CBL or CBR and stores it to *variable* on the receiving TI-83 Plus. *variable* can be a real number, list element, list name, matrix element, matrix name, string, **Y=** variable, graph database, or picture.

Get(variable)

Note: If you transfer a program that references the **Get(** command to the TI-83 Plus from a TI-82, the TI-83 Plus will interpret it as the **Get(** described above. Use **GetCalc(** to get data from another TI-83 Plus.

Send(sends the contents of *variable* to the CBL 2/CBL or CBR. You cannot use it to send to another TI-83 Plus. *variable* can be a real number, list element, list name, matrix element, matrix name, string, **Y=** variable, graph database, or picture. *variable* can be a list of elements.

Send(*variable*)

```
PROGRAM:GETSOUND  
:Send( C3,.00025,  
99,1,0,0,0,0,1)  
:Get(L1)  
:Get(L2)
```

Note: This program gets sound data and time in seconds from CBL 2/CBL.

Note: You can access **Get()**, **Send()**, and **GetCalc()** from the **CATALOG** to execute them from the home screen (Chapter 15).

Calling Other Programs as Subroutines

Calling a Program from Another Program

On the TI-83 Plus, any stored program can be called from another program as a subroutine. Enter the name of the program to use as a subroutine on a line by itself.

You can enter a program name on a command line in either of two ways.

- Press **PRGM** to display the **PRGM EXEC** menu and select the name of the program **prgmname** is pasted to the current cursor location on a command line.
- Select **prgm** from the **PRGM CTL** menu, and then enter the program name.

prgmname

When **prgmname** is encountered during execution, the next command that the program executes is the first command in the second program. It returns to the subsequent command in the first program when it encounters either **Return** or the implied **Return** at the end of the second program.

Program

```
PROGRAM:VOLCYL  
:Input "D=",D  
:Input "H=",H  
:PrgmAREACIR  
:A*H>V  
:Disp V
```

Output



```
PrgmVOLCYL  
D=4  
H=5  
62.83185307  
Done
```

Subroutine ↓↑

```
PROGRAM:AREACIR  
:D/2>R  
:π*R²>A  
:Return
```

Notes about Calling Programs

Variables are global.

label used with **Goto** and **Lbl** is local to the program where it is located.
label in one program is not recognized by another program. You cannot use **Goto** to branch to a *label* in another program.

Return exits a subroutine and returns to the calling program, even if it is encountered within nested loops.

Running an Assembly Language Program

You can run programs written for the TI-83 Plus in assembly language. Typically, assembly language programs run much faster and provide greater control than the keystroke programs that you write with the built-in program editor.

Note: Because an assembly language program has greater control over the calculator, if your assembly language program has error(s), it may cause your calculator to reset and lose all data, programs, and applications stored in memory.

When you download an assembly language program, it is stored among the other programs as a **PRGM** menu item. You can:

- Transmit it using the TI-83 Plus communication link (Chapter 19).
- Delete it using the **MEM MGMT DEL** screen (Chapter 18).

To run an assembly Program, the syntax is: **Asm(assemblyprgmname)**

If you write an assembly language program, use the two instructions below from the **CATALOG** to identify and compile the program.

| Instructions | Comments |
|--|--|
| AsmComp(<i>prgmASM1,</i> <i>prgmASM2)</i> | Compiles an assembly language program written in ASCII and stores the hex version |
| AsmPrgm | Identifies an assembly language program; must be entered as the first line of an assembly language program |

To compile an assembly program that you have written:

1. Follow the steps for writing a program (16-4) but be sure to include **AsmPrgm** as the first line of your program.
2. From the home screen, press **[2nd] [CATALOG]** and then select **AsmComp(** to paste it to the screen
3. Press **[PRGM]** to display the **PRGM EXEC** menu.
4. Select the program you want to compile. It will be pasted to the home screen.
5. Press **[** and then select **prgm** from the **CATALOG**
6. Key in the name you have chosen for the output program.

Note: This name must be unique — not a copy of an existing program name.

7. Press \square to complete the sequence.

The sequence of the arguments should be as follows:

AsmComp(*prgmASM1*, *prgmASM2*)

8. Press **[ENTER]** to compile your program and generate the output program.

Chapter 17: **Activities**

The Quadratic Formula

Entering a Calculation

Use the quadratic formula to solve the quadratic equations $3X^2 + 5X + 2 = 0$ and $2X^2 - X + 3 = 0$. Begin with the equation $3X^2 + 5X + 2 = 0$.

1. Press 3 [STO►] [ALPHA] [A] (above [MATH]) to store the coefficient of the X^2 term.
2. Press [ALPHA] [:] (above [.]). The colon allows you to enter more than one instruction on a line.
3. Press 5 [STO►] [ALPHA] [B] (above [APPS]) to store the coefficient of the X term. Press [ALPHA] [:] to enter a new instruction on the same line. Press 2 [STO►] [ALPHA] [C] (above [PRGM]) to store the constant.

3→A:5→B:2→C■

4. Press **[ENTER]** to store the values to the variables A, B, and C.

3→A:5→B:2→C
■

The last value you stored is shown on the right side of the display. The cursor moves to the next line, ready for your next entry.

5. Press **(** **(-** **ALPHA** **[B]** **+** **2nd** **[√]** **ALPHA** **[B]** ***x*²**
- **4** **ALPHA** **[A]** **ALPHA** **[C]** **)** **)** **÷** **(** **2** **ALPHA** **[A]**
) to enter the expression for one of the solutions for the quadratic formula,

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$(-B+\sqrt{(B^2-4AC)})/(2A)$ ■

6. Press **[ENTER]** to find one solution for the equation $3X^2 + 5X + 2 = 0$.

$(-B+\sqrt{(B^2-4AC)})/(2A)$ -.6666666667
■

The answer is shown on the right side of the display. The cursor moves to the next line, ready for you to enter the next expression.

The Quadratic Formula

Converting to a Fraction

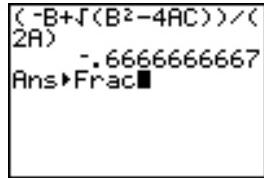
You can show the solution as a fraction.

1. Press **MATH** to display the MATH menu.

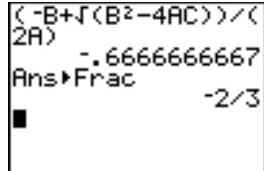


2. Press 1 to select 1:>Frac from the MATH menu.

When you press 1, **Ans>Frac** is displayed on the home screen. **Ans** is a variable that contains the last calculated answer.



3. Press **ENTER** to convert the result to a fraction.



To save keystrokes, you can recall the last expression you entered, and then edit it for a new calculation.

4. Press [2nd] [ENTRY] (above [ENTER]) to recall the fraction conversion entry, and then press [2nd] [ENTRY] again to recall the quadratic-formula expression,

$$\frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

```
(-B+√(B²-4AC))//(2A)
-.6666666667
Ans▶Frac      -2/3
(-B+√(B²-4AC))//(2A)■
```

5. Press \blacktriangleleft to move the cursor onto the + sign in the formula. Press \blacktriangleright to edit the quadratic-formula expression to become:

$$\frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

```
2A) -.6666666667
Ans▶Frac      -2/3
(-B-√(B²-4AC))//(2A)
■           -1
```

6. Press [ENTER] to find the other solution for the quadratic equation $3X^2 + 5X + 2 = 0$.

The Quadratic Formula

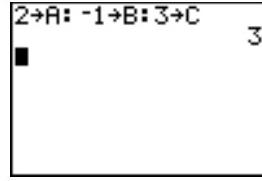
Displaying Complex Results

Now solve the equation $2X^2 - X + 3 = 0$. When you set $a+bi$ complex number mode, the TI-83 Plus displays complex results.

1. Press **MODE** \leftarrow \leftarrow \leftarrow \leftarrow \leftarrow (6 times), and then press **▶** to position the cursor over $a+bi$. Press **ENTER** to select $a+bi$ complex-number mode.



2. Press **2nd [QUIT]** (above **MODE**) to return to the home screen, and then press **CLEAR** to clear it.
3. Press **2 [STO▶] [ALPHA] [A] [ALPHA] [:] [(-) 1 [STO▶] [ALPHA] [B] [ALPHA] [:] 3 [STO▶] [ALPHA] [C] [ENTER]**.



The coefficient of the X^2 term, the coefficient of the X term, and the constant for the new equation are stored to A, B, and C, respectively.

4. Press **[2nd] [ENTRY]** to recall the store instruction, and then press **[2nd] [ENTRY]** again to recall the quadratic-formula expression,

$$\frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

2→A: -1→B: 3→C
 $\frac{(-B - \sqrt{B^2 - 4AC}))}{(2A)}$ ■
3

5. Press **[ENTER]** to find one solution for the equation $2X^2 - X + 3 = 0$.

2→A: -1→B: 3→C
 $\frac{(-B - \sqrt{B^2 - 4AC}))}{(2A)}$ ■
3
• 25-1.198957881i

6. Press **[2nd] [ENTRY]** repeatedly until this quadratic-formula expression is displayed:

$$\frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

2→A: -1→B: 3→C
 $\frac{(-B + \sqrt{B^2 - 4AC}))}{(2A)}$ ■
3
• 25-1.198957881i
• 25+1.198957881i

7. Press **[ENTER]** to find the other solution for the quadratic equation: $2X^2 - X + 3 = 0$.

Note: An alternative for solving equations for real numbers is to use the built-in Equation Solver (Chapter 2).

Box with Lid

Defining a Function

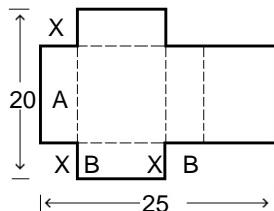
Take a $20 \text{ cm} \times 25 \text{ cm}$. sheet of paper and cut $X \times X$ squares from two corners. Cut $X \times 12.5 \text{ cm}$ rectangles from the other two corners as shown in the diagram below. Fold the paper into a box with a lid. What value of X would give your box the maximum volume V ? Use the table and graphs to determine the solution.

Begin by defining a function that describes the volume of the box.

From the diagram: $2X + A = 20$

$$2X + 2B = 25$$

$$V = A \cdot B \cdot X$$



Substituting: $V = (20 - 2X)(25/2 - X)X$

1. Press **[Y=]** to display the **Y=** editor, which is where you define functions for tables and graphing.

| | | |
|-------------------------------------|-------|-------|
| Plot1 | Plot2 | Plot3 |
| $\text{Y}_1 =$ <input type="text"/> | | |
| $\text{Y}_2 =$ <input type="text"/> | | |
| $\text{Y}_3 =$ <input type="text"/> | | |
| $\text{Y}_4 =$ <input type="text"/> | | |
| $\text{Y}_5 =$ <input type="text"/> | | |
| $\text{Y}_6 =$ <input type="text"/> | | |
| $\text{Y}_7 =$ <input type="text"/> | | |

2. Press $\boxed{2}$ $\boxed{0}$ $\boxed{-}$ $\boxed{2}$ $\boxed{X,T,\Theta,n}$ $\boxed{)}$ $\boxed{\times}$ $\boxed{25}$ $\boxed{\div}$ $\boxed{2}$ $\boxed{X,T,\Theta,n}$ $\boxed{)}$ $\boxed{X,T,\Theta,n}$ $\boxed{[ENTER]}$ to define the volume function as Y_1 in terms of X .

$\boxed{X,T,\Theta,n}$ lets you enter X quickly, without having to press $\boxed{\text{ALPHA}}$. The highlighted = sign indicates that Y_1 is selected.

```
Plot1 Plot2 Plot3
Y1=(20-2X)(25/2
-X)X
Y2=
Y3=
Y4=
Y5=
Y6=
```

Box with Lid

Defining a Table of Values

The table feature of the TI-83 Plus displays numeric information about a function. You can use a table of values from the function you just defined to estimate an answer to the problem.

1. Press $\boxed{2nd}$ $\boxed{[TBLSET]}$ (above $\boxed{\text{WINDOW}}$) to display the TABLE SETUP menu.
2. Press $\boxed{[ENTER]}$ to accept $\text{TblStart}=0$.
3. Press $\boxed{1}$ $\boxed{[ENTER]}$ to define the table increment $\Delta\text{Tbl}=1$. Leave **Indpt: Auto** and **Depend: Auto** so that the table will be generated automatically.

```
TABLE SETUP
TblStart=0
ΔTbl=1
Indpt: Auto Ask
Depend: Auto Ask
```

4. Press **[2nd] [TABLE]** (above **[GRAPH]**) to display the table.

Notice that the maximum value for **Y₁** (box's volume) occurs when **X** is about 4, between 3 and 5.

5. Press and hold **[▼]** to scroll the table until a negative result for **Y₁** is displayed.

Notice that the maximum length of **X** for this problem occurs where the sign of **Y₁** (box's volume) changes from positive to negative, between **10** and **11**.

6. Press **[2nd] [TBLSET]**.

Notice that **TblStart** has changed to **6** to reflect the first line of the table as it was last displayed. (In step 5, the first value of **X** displayed in the table is **6**.)

| X | Y ₁ | |
|---|----------------|--|
| 0 | 0 | |
| 1 | 207 | |
| 2 | 326 | |
| 3 | 399 | |
| 4 | 408 | |
| 5 | 325 | |
| 6 | 312 | |

X=0

| X | Y ₁ | |
|----|----------------|--|
| 6 | 312 | |
| 7 | 231 | |
| 8 | 144 | |
| 9 | 63 | |
| 10 | 0 | |
| 11 | -33 | |
| 12 | -24 | |

X=12

| TABLE SETUP | |
|-------------|----------|
| TblStart= | 6 |
| △Tbl= | 1 |
| IndPnt: | Auto Ask |
| Depend: | Auto Ask |

Box with Lid

Zooming In on the Table

You can adjust the way a table is displayed to get more information about a defined function. With smaller values for ΔTbl , you can zoom in on the table.

1. Press **3 [ENTER]** to set **TblStart**. Press **1 [ENTER]** to set ΔTbl .

This adjusts the table setup to get a more accurate estimate of **X** for maximum volume **Y1**.

| TABLE SETUP | |
|-----------------------|-----|
| TblStart=3 | |
| $\Delta\text{Tbl}=.1$ | |
| Indent: Auto | Ask |
| Defend: Auto | Ask |

2. Press **[2nd] [TABLE]**.
3. Press **▼** and **▲** to scroll the table.

Notice that the maximum value for **Y1** is **410.26**, which occurs at **X=3.7**. Therefore, the maximum occurs where **3.6 < X < 3.8**.

| X | Y1 |
|-----|--------|
| 3.6 | 410.11 |
| 3.7 | 410.26 |
| 3.8 | 409.94 |
| 3.9 | 409.19 |
| 4 | 408 |
| 4.1 | 406.39 |
| 4.2 | 404.38 |

4. Press **2nd** [TBLSET]. Press **3** **.** **6** [**ENTER**] to set **TblStart**. Press **.** **01** [**ENTER**] to set ΔTbl .

| TABLE SETUP | |
|--------------------|----------|
| TblStart | =3.6 |
| ΔTbl | =.01 |
| IndPnt: | Auto Ask |
| Depend: | Auto Ask |

5. Press **2nd** [TABLE], and then press **▼** and **▲** to scroll the table.

Four equivalent maximum values are shown,
410.26 at **X=3.67**, **3.68**, **3.69**, and **3.70**.

6. Press **▼** or **▲** to move the cursor to **3.67**. Press **▶** to move the cursor into the **Y1** column.

The value of **Y1** at **X=3.67** is displayed on the bottom line in full precision as **410.261226**.

| X | Y1 |
|------|--------|
| 3.66 | 410.25 |
| 3.67 | 410.26 |
| 3.68 | 410.26 |
| 3.69 | 410.26 |
| 3.7 | 410.26 |
| 3.71 | 410.25 |
| 3.72 | 410.23 |

X=3.72

| X | Y1 |
|------|--------|
| 3.66 | 410.25 |
| 3.67 | 410.26 |
| 3.68 | 410.26 |
| 3.69 | 410.26 |
| 3.7 | 410.26 |
| 3.71 | 410.25 |
| 3.72 | 410.23 |

Y1=410.261226

7. Press **▼** to display the other maximum.

The value of Y_1 at $X=3.68$ in full precision is **410.264064**, at $X=3.69$ is **410.262318** and at $X=3.7$ is **410.256**.

| X | Y_1 |
|------|-------------------|
| 3.66 | 410.25 |
| 3.67 | 410.26 |
| 3.68 | 410.264064 |
| 3.69 | 410.26 |
| 3.70 | 410.26 |
| 3.71 | 410.25 |
| 3.72 | 410.25 |

$Y_1 = 410.264064$

The maximum volume of the box would occur at **3.68** if you could measure and cut the paper at .01-centimeter increments.

Box with Lid

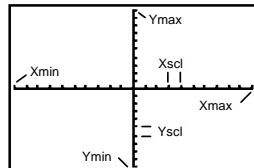
Setting the Viewing Window

You also can use the graphing features of the TI-83 Plus to find the maximum value of a previously defined function. When the graph is activated, the viewing window defines the displayed portion of the coordinate plane. The values of the window variables determine the size of the viewing window.

1. Press **WINDOW** to display the window editor, where you can view and edit the values of the window variables.

| WINDOW |
|------------------------|
| $X_{\text{min}} = -10$ |
| $X_{\text{max}} = 10$ |
| $X_{\text{scl}} = 1$ |
| $Y_{\text{min}} = -10$ |
| $Y_{\text{max}} = 10$ |
| $Y_{\text{scl}} = 1$ |
| $X_{\text{res}} = 1$ |

The standard window variables define the viewing window as shown. **Xmin**, **Xmax**, **Ymin**, and **Ymax** define the boundaries of the display. **Xscl** and **Yscl** define the distance between tick marks on the **X** and **Y** axes. **Xres** controls resolution.



2. Press **0 [ENTER]** to define **Xmin**.
3. Press **20 ÷ 2** to define **Xmax** using an expression.
4. Press **[ENTER]**. The expression is evaluated, and **10** is stored in **Xmax**. Press **[ENTER]** to accept **Xscl** as **1**.
5. Press **0 [ENTER] 500 [ENTER] 100 [ENTER] 1 [ENTER]** to define the remaining window variables.

```
WINDOW
Xmin=0
Xmax=20/2
Xscl=1
Ymin=-10
Ymax=10
Yscl=1
Xres=1
```

```
WINDOW
Xmin=0
Xmax=10
Xscl=1
Ymin=0
Ymax=500
Yscl=100
Xres=1
```

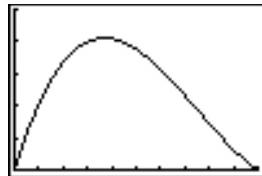
Box with Lid

Displaying and Tracing the Graph

Now that you have defined the function to be graphed and the window in which to graph it, you can display and explore the graph. You can trace along a function using the **TRACE** feature.

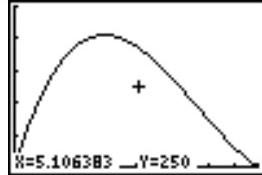
1. Press **[GRAPH]** to graph the selected function in the viewing window.

The graph of $Y_1=(20-2X)(25/2-X)X$ is displayed.



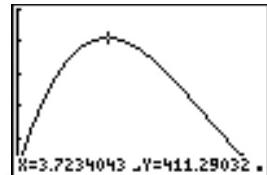
2. Press **[▼]** to activate the free-moving graph cursor.

The **X** and **Y** coordinate values for the position of the graph cursor are displayed on the bottom line.



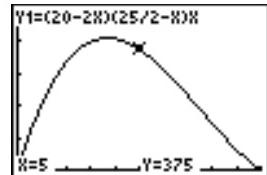
3. Press \blacktriangleleft , \triangleright , \blacktriangleup , and \blacktriangledown to move the free-moving cursor to the apparent maximum of the function.

As you move the cursor, the X and Y coordinate values are updated continually.



4. Press **TRACE**. The trace cursor is displayed on the Y_1 function.

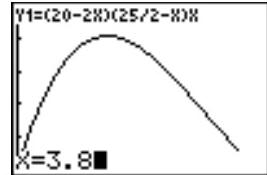
The function that you are tracing is displayed in the top-left corner.



5. Press \blacktriangleleft and \triangleright to trace along Y_1 , one X dot at a time, evaluating Y_1 at each X.

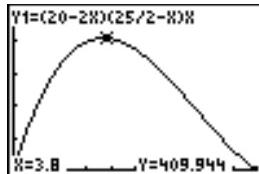
You also can enter your estimate for the maximum value of X.

6. Press **3** **8**. When you press a number key while in **TRACE**, the X= prompt is displayed in the bottom-left corner.



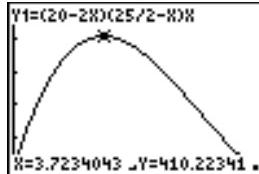
7. Press **[ENTER]**.

The trace cursor jumps to the point on the Y_1 function evaluated at $X=3.8$.



8. Press **[◀]** and **[▶]** until you are on the maximum Y value.

This is the maximum of $Y_1(X)$ for the X pixel values. The actual, precise maximum may lie between pixel values.



Box with Lid

Zooming In on the Graph

To help identify maximums, minimums, roots, and intersections of functions, you can magnify the viewing window at a specific location using the **ZOOM** instructions.

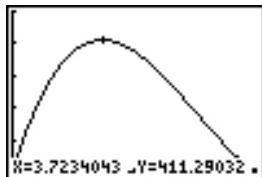
1. Press **ZOOM** to display the **ZOOM** menu.

This menu is a typical TI-83 Plus menu. To select an item, you can either press the number or letter next to the item, or you can press **▼** until the item number or letter is highlighted, and then press **ENTER**.



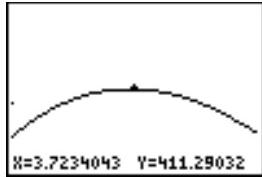
2. Press **2** to select **2:Zoom In**.

The graph is displayed again. The cursor has changed to indicate that you are using a **ZOOM** instruction.



3. With the cursor near the maximum value of the function, press **ENTER**.

The new viewing window is displayed. Both **Xmax**–**Xmin** and **Ymax**–**Ymin** have been adjusted by factors of 4, the default values for the zoom factors.



4. Press **[WINDOW]** to display the new window settings.

```
WINDOW  
Xmin=2.4734042  
Xmax=4.9734042...  
Xscl=1  
Ymin=348.79032...  
Ymax=473.79032...  
Yscl=100  
Xres=1
```

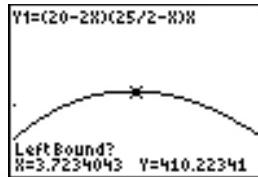
Box with Lid

Finding the Calculated Maximum

You can use a **CALCULATE** menu operation to calculate a local maximum of a function.

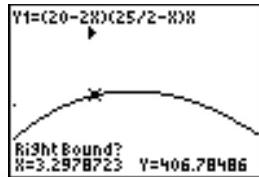
1. Press **[2nd] [CALC]** (above **TRACE**) to display the **CALCULATE** menu. Press **4** to select **4:maximum**.

The graph is displayed again with a **Left Bound?** prompt.



2. Press \blacktriangleleft to trace along the curve to a point to the left of the maximum, and then press [ENTER].

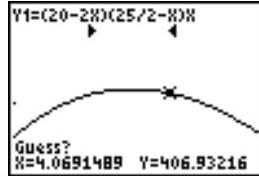
A \triangleright at the top of the screen indicates the selected bound.



A Right Bound? prompt is displayed.

3. Press \triangleright to trace along the curve to a point to the right of the maximum, and then press [ENTER].

A \blacktriangleleft at the top of the screen indicates the selected bound.



A Guess? prompt is displayed.

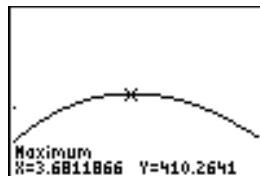
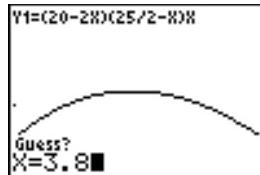
4. Press \blacktriangleleft to trace to a point near the maximum, and then press [ENTER].

Or, press **3** **.** **8**, and then press **ENTER** to enter a guess for the maximum.

When you press a number key in **TRACE**, the **X=** prompt is displayed in the bottom-left corner.

Notice how the values for the calculated maximum compare with the maximums found with the free-moving cursor, the trace cursor, and the table.

Note: In steps 2 and 3 above, you can enter values directly for Left Bound and Right Bound, in the same way as described in step 4.



Comparing Test Results Using Box Plots

Problem

An experiment found a significant difference between boys and girls pertaining to their ability to identify objects held in their left hands, which are controlled by the right side of their brains, versus their right hands, which are controlled by the left side of their brains. The TI Graphics team conducted a similar test for adult men and women.

The test involved 30 small objects, which participants were not allowed to see. First, they held 15 of the objects one by one in their left hands and guessed what they were. Then they held the other 15 objects one by one in their right hands and guessed what they were. Use box plots to compare visually the correct-guess data from this table.

Correct Guesses

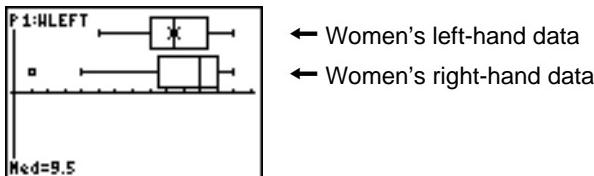
| Women Left | Women Right | Men Left | Men Right |
|---------------|----------------|-------------|--------------|
| 8 | 4 | 7 | 12 |
| 9 | 1 | 8 | 6 |
| 12 | 8 | 7 | 12 |
| 11 | 12 | 5 | 12 |
| 10 | 11 | 7 | 7 |
| 8 | 11 | 8 | 11 |

| Women Left | Women Right | Men Left | Men Right |
|---------------|----------------|-------------|--------------|
| 12 | 13 | 11 | 12 |
| 7 | 12 | 4 | 8 |
| 9 | 11 | 10 | 12 |
| 11 | 12 | 14 | 11 |
| | | 13 | 9 |
| | | 5 | 9 |

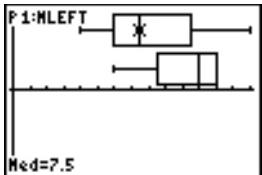
Procedure

1. Press **STAT** 5 to select **5:SetUpEditor**. Enter list names **WLEFT**, **WRGHT**, **MLEFT**, and **MRGHT**, separated by commas. Press **ENTER**. The stat list editor now contains only these four lists.
2. Press **STAT** 1 to select **1>Edit**.
3. Enter into **WLEFT** the number of correct guesses each woman made using her left hand (**Women Left**). Press **►** to move to **WRGHT** and enter the number of correct guesses each woman made using her right hand (**Women Right**).
4. Likewise, enter each man's correct guesses in **MLEFT** (**Men Left**) and **MRGHT** (**Men Right**).

5. Press **[2nd] [STAT PLOT]**. Select **1:Plot1**. Turn on plot 1; define it as a modified box plot **HLEFT** that uses **WLEFT**. Move the cursor to the top line and select **Plot2**. Turn on plot 2; define it as a modified box plot that uses **WRGHT**.
6. Press **[Y=]**. Turn off all functions.
7. Press **[WINDOW]**. Set **Xscl=1** and **Yscl=0**. Press **[ZOOM] 9** to select **9:ZoomStat**. This adjusts the viewing window and displays the box plots for the women's results.
8. Press **[TRACE]**.



- Use **[◀]** and **[▶]** to examine **minX**, **Q1**, **Med**, **Q3**, and **maxX** for each plot. Notice the outlier to the women's right-hand data. What is the median for the left hand? For the right hand? With which hand were the women more accurate guessers, according to the box plots?
9. Examine the men's results. Redefine plot 1 to use **MLEFT**, redefine plot 2 to use **MRGHT**. Press **[TRACE]**.



Press \blacktriangleleft and \triangleright to examine **minX**, **Q1**, **Med**, **Q3**, and **maxX** for each plot. What difference do you see between the plots?

10. Compare the left-hand results. Redefine plot 1 to use **WLEFT**, redefine plot 2 to use **MLEFT**, and then press **TRACE** to examine **minX**, **Q1**, **Med**, **Q3**, and **maxX** for each plot. Who were the better left-hand guessers, men or women?
11. Compare the right-hand results. Define plot 1 to use **WRGHT**, define plot 2 to use **MRGHT**, and then press **TRACE** to examine **minX**, **Q1**, **Med**, **Q3**, and **maxX** for each plot. Who were the better right-hand guessers?

In the original experiment boys did not guess as well with right hands, while girls guessed equally well with either hand. This is not what our box plots show for adults. Do you think that this is because adults have learned to adapt or because our sample was not large enough?

Graphing Piecewise Functions

Problem

The fine for speeding on a road with a speed limit of 45 kilometers per hour (kph) is 50; plus 5 for each kph from 46 to 55 kph; plus 10 for each kph from 56 to 65 kph; plus 20 for each kph from 66 kph and above. Graph the piecewise function that describes the cost of the ticket.

The fine (Y) as a function of kilometers per hour (X) is:

| | |
|--|------------------|
| $Y = 0$ | $0 < X \leq 45$ |
| $Y = 50 + 5(X - 45)$ | $45 < X \leq 55$ |
| $Y = 50 + 5 * 10 + 10(X - 55)$ | $55 < X \leq 65$ |
| $Y = 50 + 5 * 10 + 10 * 10 + 20(X - 65)$ | $65 < X$ |

Procedure

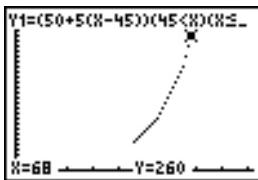
1. Press **MODE**. Select **Func** and the default settings.
2. Press **Y=**. Turn off all functions and stat plots. Enter the **Y=** function to describe the fine. Use the **TEST** menu operations to define the piecewise function. Set the graph style for **Y1** to **.** (dot).

```

Plot1 Plot2 Plot3
:Y1=(50+5(X-45))
(45<X)(X≤55)+(10
0+10(X-55))(55<X
)(X≤65)+(200+20(
X-65))(65<X)■
:Y2=
:Y3=

```

- Press **WINDOW** and set **Xmin=-2**, **Xscl=10**, **Ymin=-5**, and **Yscl=10**. Ignore **Xmax** and **Ymax**; they are set by ΔX and ΔY in step 4.
- Press **2nd [QUIT]** to return to the home screen. Store 1 to ΔX , and then store 5 to ΔY . ΔX and ΔY are on the **VARS Window X/Y** secondary menu. ΔX and ΔY specify the horizontal and vertical distance between the centers of adjacent pixels. Integer values for ΔX and ΔY produce nice values for tracing.
- Press **TRACE** to plot the function. At what speed does the ticket exceed 250?



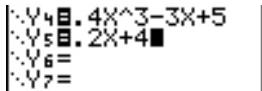
Graphing Inequalities

Problem

Graph the inequality $0.4X^3 - 3X + 5 < 0.2X + 4$. Use the **TEST** menu operations to explore the values of X where the inequality is true and where it is false.

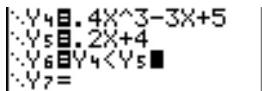
Procedure

1. Press **[MODE]**. Select **Dot**, **Simul**, and the default settings. Setting **Dot** mode changes all graph style icons to '•' (dot) in the **Y=** editor.
2. Press **[Y=]**. Turn off all functions and stat plots. Enter the left side of the inequality as **Y4** and the right side as **Y5**.



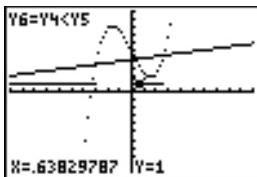
```
[Y4=.4X^3-3X+5  
Y5=2X+4  
Y6=  
Y7=
```

3. Enter the statement of the inequality as **Y6**. This function evaluates to **1** if true or **0** if false.



```
[Y4=.4X^3-3X+5  
Y5=2X+4  
Y6=Y4 < Y5  
Y7=
```

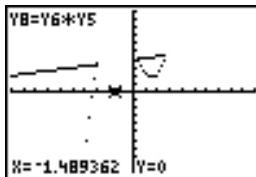
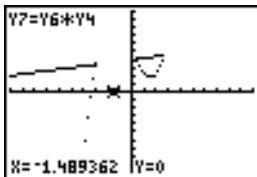
4. Press **ZOOM** 6 to graph the inequality in the standard window.
5. Press **TRACE** **▼** **▼** to move to **Y6**. Then press **◀** and **▶** to trace the inequality, observing the value of Y.



6. Press **[Y=]**. Turn off **Y4**, **Y5**, and **Y6**. Enter equations to graph only the inequality.

```
:Y4=.4X^3-3X+5  
:Y5=.2X+4  
:Y6=Y4<Y5  
:Y7=Y6*Y4  
:Y8=Y6*Y5
```

7. Press **TRACE**. Notice that the values of **Y7** and **Y8** are zero where the inequality is false.



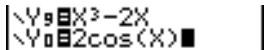
Solving a System of Nonlinear Equations

Problem

Using a graph, solve the equation $X^3 - 2X = 2\cos(X)$. Stated another way, solve the system of two equations and two unknowns: $Y = X^3 - 2X$ and $Y = 2\cos(X)$. Use **ZOOM** factors to control the decimal places displayed on the graph.

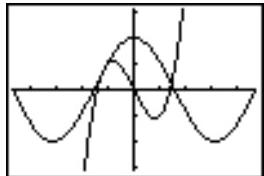
Procedure

1. Press **MODE**. Select the default mode settings. Press **Y=**. Turn off all functions and stat plots. Enter the functions.



The image shows a portion of a graphing calculator's display. It displays two lines of function definitions: $\text{Y1} \text{=} \text{X}^3 - 2\text{X}$ and $\text{Y2} \text{=} 2\cos(\text{X})$. The text is in a monospaced font, typical of a calculator's menu or entry screen.

2. Press **ZOOM** 4 to select 4:ZDecimal. The display shows that two solutions may exist (points where the two functions appear to intersect).



3. Press **ZOOM** ▶ 4 to select **4:SetFactors** from the **ZOOM MEMORY** menu. Set **XFact=10** and **YFact=10**.
4. Press **ZOOM** 2 to select **2:Zoom In**. Use **◀**, **▶**, **▲**, and **▼** to move the free-moving cursor onto the apparent intersection of the functions on the right side of the display. As you move the cursor, notice that the **X** and **Y** values have one decimal place.
5. Press **ENTER** to zoom in. Move the cursor over the intersection. As you move the cursor, notice that now the **X** and **Y** values have two decimal places.
6. Press **ENTER** to zoom in again. Move the free-moving cursor onto a point exactly on the intersection. Notice the number of decimal places.
7. Press **2nd** [CALC] 5 to select **5:intersect**. Press **ENTER** to select the first curve and **ENTER** to select the second curve. To guess, move the trace cursor near the intersection. Press **ENTER**. What are the coordinates of the intersection point?
8. Press **ZOOM** 4 to select **4:ZDecimal** to redisplay the original graph.
9. Press **ZOOM**. Select **2:Zoom In** and repeat steps 4 through 8 to explore the apparent function intersection on the left side of the display.

Using a Program to Create the Sierpinski Triangle

Setting up the Program

This program creates a drawing of a famous fractal, the Sierpinski Triangle, and stores the drawing to a picture. To begin, press **PRGM** ▶ ▶
1. Name the program **SIERPINS**, and then press **ENTER**. The program editor is displayed.

Program

```
PROGRAM:SIERPINS
:FnOff :ClrDraw
:PlotsOff
:AxesOff
:0→Xmin:1→Xmax
:0→Ymin:1→Ymax
:rand→X:rand→Y
:For(K,1,3000)
:rand→N
:If N≤1/3
:Then
:.5X→X
:.5Y→Y
:End
```

-]- Set viewing window.
-]- Beginning of **For** group.
-]- **If/Then** group

```

:If 1/3<N and N≤2/3
:Then
:.5(.5+X)→X
:.5(1+Y)→Y
:End
:If 2/3<N
:Then
:.5(1+X)→X
:.5Y→Y
:End
:Pt-On(X,Y)
:End
:StorePic 6

```

} If/Then group.

} If/Then group.

Draw point.

End of For group.

Store picture.

After you execute the program above, you can recall and display the picture with the instruction **RecallPic 6**.



Graphing Cobweb Attractors

Problem

Using **Web** format, you can identify points with attracting and repelling behavior in sequence graphing.

Procedure

1. Press **[MODE]**. Select **Seq** and the default mode settings. Press **[2nd]** **[FORMAT]**. Select **Web** format and the default format settings.
2. Press **[Y=]**. Clear all functions and turn off all stat plots. Enter the sequence that corresponds to the expression $Y = K X(1-X)$.

$$u(n)=Ku(n-1)(1-u(n-1))$$

$$u(nMin)=.01$$

3. Press **[2nd]** **[QUIT]** to return to the home screen, and then store **2.9** to **K**.
4. Press **[WINDOW]**. Set the window variables.

$$nMin=0$$

$$Xmin=0$$

$$Ymin=-.26$$

$$nMax=10$$

$$Xmax=1$$

$$Ymax=1.1$$

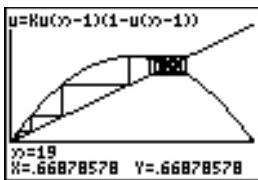
$$PlotStart=1$$

$$Xscl=1$$

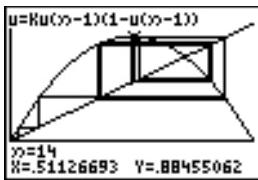
$$Yscl=1$$

$$PlotStep=1$$

5. Press **TRACE** to display the graph, and then press **►** to trace the cobweb. This is a cobweb with one attractor.



6. Change **K** to **3.44** and trace the graph to show a cobweb with two attractors.
7. Change **K** to **3.54** and trace the graph to show a cobweb with four attractors.



Using a Program to Guess the Coefficients

Setting Up the Program

This program graphs the function $A \sin(BX)$ with random integer coefficients between 1 and 10. Try to guess the coefficients and graph your guess as $C \sin(DX)$. The program continues until your guess is correct.

Program

```
PROGRAM:GUESS
:PlotsOff :Func
:FnOff :Radian
:ClrHome
:"Asin(BX)">Y1
:"Csin(DX)">Y2
:GraphStyle(1,1)
:GraphStyle(2,5)
:FnOff 2
:randInt(1,10)>A
:randInt(1,10)>B
:0>C:0>D
:-2π>Xmin
:2π>Xmax
:π/2>Xscl
:-10>Ymin
:10>Ymax
```

]- Define equations.
]- Set line and path graph styles.
]- Initialize coefficients.
]- Set viewing window.

```
:1→Ysc1  
:DispGraph  
:Pause  
:FnOn 2  
:Lbl Z  
:Prompt C,D  
:DispGraph  
:Pause  
:If C=A  
:Text(1,1,"C IS OK")  
:If C≠A  
:Text(1,1,"C IS WRONG")  
:If D=B  
:Text(1,50,"D IS OK")  
:If D≠B  
:Text(1,50,"D IS WRONG")  
:DispGraph  
:Pause  
:If C=A and D=B  
:Stop  
:Goto Z
```

Diagram illustrating the logic flow of the TI-BASIC program:

- Initial setup:
 - :1→Ysc1
 - :DispGraph
 - :Pause
- Display graph:
 - :FnOn 2
 - :Lbl Z
 - :Prompt C,D
 - :DispGraph
 - :Pause
- Prompt for guess:
 - :If C=A
 - :Text(1,1,"C IS OK")
 - :If C≠A
 - :Text(1,1,"C IS WRONG")
- Display results:
 - :If D=B
 - :Text(1,50,"D IS OK")
 - :If D≠B
 - :Text(1,50,"D IS WRONG")
- Final steps:
 - :DispGraph
 - :Pause
 - :If C=A and D=B
 - :Stop
 - :Goto Z

Graphing the Unit Circle and Trigonometric Curves

Problem

Using parametric graphing mode, graph the unit circle and the sine curve to show the relationship between them.

Any function that can be plotted in **Func** mode can be plotted in **Par** mode by defining the **X** component as **T** and the **Y** component as **F(T)**.

Procedure

1. Press **MODE**. Select **Par**, **Simul**, and the default settings.
2. Press **WINDOW**. Set the viewing window.

$$T_{\min}=0$$

$$X_{\min}=-2$$

$$Y_{\min}=-3$$

$$T_{\max}=2\pi$$

$$X_{\max}=7.4$$

$$Y_{\max}=3$$

$$T_{\text{step}}=.\,1$$

$$X_{\text{scl}}=\pi/2$$

$$Y_{\text{scl}}=1$$

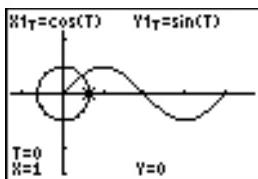
3. Press **Y=**. Turn off all functions and stat plots. Enter the expressions to define the unit circle centered on (0,0).

```
Plot1 Plot2 Plot3  
X1T=cos(T)  
Y1T=sin(T)  
X2T=T  
Y2T=sin(T)
```

4. Enter the expressions to define the sine curve.

```
Plot1 Plot2 Plot3  
X1T=cos(T)  
Y1T=sin(T)  
X2T=T  
Y2T=sin(T)
```

5. Press **TRACE**. As the graph is plotting, you may press **ENTER** to pause and **ENTER** again to resume graphing as you watch the sine function “unwrap” from the unit circle.



Note: You can generalize the unwrapping. Replace $\sin(T)$ in Y_2T with any other trig function to unwrap that function.

Finding the Area between Curves

Problem

Find the area of the region bounded by

$$f(x) = 300x/(x^2 + 625)$$

$$g(x) = 3\cos(.1x)$$

$$x = 75$$

Procedure

1. Press **MODE**. Select the default mode settings.

2. Press **WINDOW**. Set the viewing window.

$$X_{\min}=0 \qquad Y_{\min}=-5$$

$$X_{\max}=100 \qquad Y_{\max}=10$$

$$X_{\text{scl}}=10 \qquad Y_{\text{scl}}=1$$

$$X_{\text{res}}=1$$

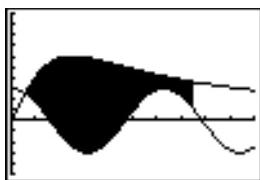
3. Press **Y=**. Turn off all functions and stat plots. Enter the upper and lower functions.

$$Y_1=300X/(X^2+625)$$

$$Y_2=3\cos(.1X)$$

4. Press **[2nd]** **[CALC]** **5** to select **5:Intersect**. The graph is displayed. Select a first curve, second curve, and guess for the intersection toward the left side of the display. The solution is displayed, and the value of **X** at the intersection, which is the lower limit of the integral, is stored in **Ans** and **X**.
5. Press **[2nd]** **[QUIT]** to go to the home screen. Press **[2nd]** **[DRAW]** **7** and use **Shade(** to see the area graphically.

Shade(Y2,Y1,Ans,75)



6. Press **[2nd]** **[QUIT]** to return to the home screen. Enter the expression to evaluate the integral for the shaded region.

fnInt(Y1-Y2,X,Ans,75)

The area is **325.839962**.

Using Parametric Equations: Ferris Wheel Problem

Problem

Using two pairs of parametric equations, determine when two objects in motion are closest to each other in the same plane.

A ferris wheel has a diameter (d) of 20 meters and is rotating counterclockwise at a rate (s) of one revolution every 12 seconds. The parametric equations below describe the location of a ferris wheel passenger at time T , where α is the angle of rotation, $(0,0)$ is the bottom center of the ferris wheel, and $(10,10)$ is the passenger's location at the rightmost point, when $T=0$.

$$X(T) = r \cos \alpha \quad \text{where } \alpha = 2\pi Ts \text{ and } r = d/2$$
$$Y(T) = r + r \sin \alpha$$

A person standing on the ground throws a ball to the ferris wheel passenger. The thrower's arm is at the same height as the bottom of the ferris wheel, but 25 meters (b) to the right of the ferris wheel's lowest point $(25,0)$. The person throws the ball with velocity (v_0) of 22 meters per second at an angle (θ) of 66° from the horizontal. The parametric equations below describe the location of the ball at time T .

$$X(T) = b - T v_0 \cos \theta$$
$$Y(T) = T v_0 \sin \theta - (g/2) T^2 \quad \text{where } g = 9.8 \text{ m/sec}^2$$

Procedure

1. Press **MODE**. Select **Par**, **Simul**, and the default settings. **Simul** (simultaneous) mode simulates the two objects in motion over time.
2. Press **WINDOW**. Set the viewing window.

Tmin=0

Xmin=-13

Ymin=0

Tmax=12

Xmax=34

Ymax=31

Tstep=.1

Xscl=10

Yscl=10

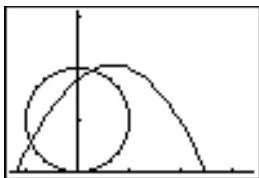
3. Press **Y=**. Turn off all functions and stat plots. Enter the expressions to define the path of the ferris wheel and the path of the ball. Set the graph style for **X2T** to \diamond (path).

```
Plot1 Plot2 Plot3  
X1T 10cos(πT/6)  
Y1T 10+10sin(πT  
/6)  
X2T 25-22Tcos(6  
6°)  
Y2T 22Tsin(66°)
```

$-(9.8/2)T^2$

Tip: Try setting the graph styles to \diamond **X1T** and \diamond **X2T**, which simulates a chair on the ferris wheel and the ball flying through the air when you press **GRAPH**.

4. Press **[GRAPH]** to graph the equations. Watch closely as they are plotted. Notice that the ball and the ferris wheel passenger appear to be closest where the paths cross in the top-right quadrant of the ferris wheel.



5. Press **[WINDOW]**. Change the viewing window to concentrate on this portion of the graph.

Tmin=1

Xmin=0

Ymin=10

Tmax=3

Xmax=23.5

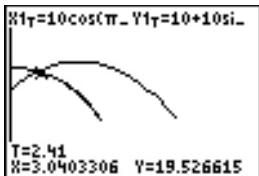
Ymax=25.5

Tstep=.03

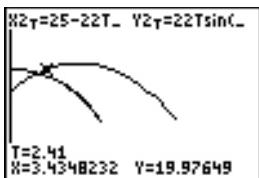
Xscl=10

Yscl=10

6. Press **[TRACE]**. After the graph is plotted, press **[▼]** to move near the point on the ferris wheel where the paths cross. Notice the values of **X**, **Y**, and **T**.



7. Press \blacktriangleleft to move to the path of the ball. Notice the values of X and Y (T is unchanged). Notice where the cursor is located. This is the position of the ball when the ferris wheel passenger passes the intersection. Did the ball or the passenger reach the intersection first?



You can use **TRACE** to, in effect, take snapshots in time and explore the relative behavior of two objects in motion.

Demonstrating the Fundamental Theorem of Calculus

Problem 1

Using the functions **f_nInt(** and **nDeriv(** from the **MATH** menu to graph functions defined by integrals and derivatives demonstrates graphically that:

$$F(x) = \int_1^x \frac{1}{t} dt = \ln(x), \quad x > 0 \quad \text{and that}$$

$$Dx \left[\int_1^x \frac{1}{t} dt \right] = \frac{1}{x}$$

Procedure 1

1. Press **MODE**. Select the default settings.
2. Press **WINDOW**. Set the viewing window.

Xmin=.01

Ymin=-1.5

Xres=3

Xmax=10

Ymax=2.5

Xscl=1

Yscl=1

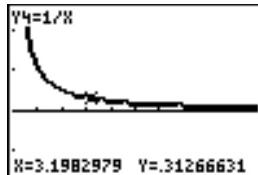
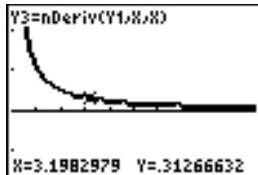
3. Press **[Y=]**. Turn off all functions and stat plots. Enter the numerical integral of $1/T$ from 1 to X and the function $\ln(X)$. Set the graph style for Y_1 to ~ (line) and Y_2 to ~! (path).

```
Plot1 Plot2 Plot3  
Y1=fnInt(1/T,T,  
1,X)  
Y2=ln(X)
```

4. Press **[TRACE]**. Press **[◀]**, **[▲]**, **[▶]**, and **[▼]** to compare the values of Y_1 and Y_2 .
5. Press **[Y=]**. Turn off Y_1 and Y_2 , and then enter the numerical derivative of the integral of $1/X$ and the function $1/X$. Set the graph style for Y_3 to ~ (line) and Y_4 to ~! (thick).

```
Plot1 Plot2 Plot3  
Y1=fnInt(1/T,T,  
1,X)  
Y2=ln(X)  
Y3=nDeriv(Y1,X,  
X)  
Y4=1/X
```

6. Press **[TRACE]**. Again, use the cursor keys to compare the values of the two graphed functions, Y_3 and Y_4 .



Problem 2

Explore the functions defined by

$$y = \int_2^x t^2 dt, \quad \int_0^x t^2 dt, \quad \text{and} \quad \int_2^x t^2 dt,$$

Procedure 2

1. Press **[Y=]**. Turn off all functions and stat plots. Use a list to define these three functions simultaneously. Store the function in **Y5**.

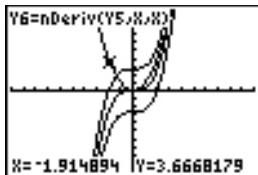
```
Plot1 Plot2 Plot3
1,X)
\Y2=ln(X)
\Y3=nDeriv(Y1,X,
X)
\Y4=1/X
\Y5 fnInt(T^2,T,{-2,0,23,X})
```

2. Press **[ZOOM] 6** to select **6:ZStandard**.
3. Press **[TRACE]**. Notice that the functions appear identical, only shifted vertically by a constant.

4. Press **[Y=]**. Enter the numerical derivative of **Y5** in **Y6**.

```
Plot1 Plot2 Plot3  
\Y3=nDeriv(Y1,X,  
X)  
\Y4=1/X  
\Y5 fnInt(T^2,T,  
-2,0,2),X)  
\Y6=nDeriv(Y5,X,  
X)
```

5. Press **[TRACE]**. Notice that although the three graphs defined by **Y5** are different, they share the same derivative.

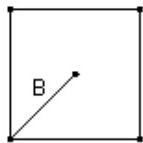


Computing Areas of Regular N-Sided Polygons

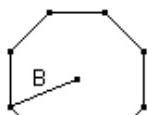
Problem

Use the equation solver to store a formula for the area of a regular N-sided polygon, and then solve for each variable, given the other variables. Explore the fact that the limiting case is the area of a circle, πr^2 .

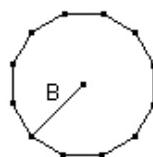
Consider the formula $A = NB^2 \sin(\pi/N) \cos(\pi/N)$ for the area of a regular polygon with N sides of equal length and B distance from the center to a vertex.



N = 4 sides



N = 8 sides



N = 12 sides

Procedure

1. Press **MATH** 0 to select **0:Solver** from the **MATH** menu. Either the equation editor or the interactive solver editor is displayed. If the

interactive solver editor is displayed, press \blacktriangleleft to display the equation editor.

- Enter the formula as $0=A-NB^2\sin(\pi / N)\cos(\pi / N)$, and then press [ENTER]. The interactive solver editor is displayed.

```
A-NB2*sin(π/N)...=0
A=0
N=0
B=0
bound=[-1e99, 1...
```

- Enter **N=4** and **B=6** to find the area (**A**) of a square with a distance (**B**) from center to vertex of 6 centimeters.
- Press \blacktriangleleft \blacktriangleright to move the cursor onto **A**, and then press [ALPHA] [SOLVE]. The solution for **A** is displayed on the interactive solver editor.

```
A-NB2*sin(π/N)...=0
• A=72.000000000...
N=4
B=6
bound=[-1e99, 1...
• left-right=0
```

- Now solve for **B** for a given area with various number of sides. Enter **A=200** and **N=6**. To find the distance **B**, move the cursor onto **B**, and then press [ALPHA] [SOLVE].

6. Enter **N=8**. To find the distance **B**, move the cursor onto **B**, and then press **[ALPHA] [SOLVE]**. Find **B** for **N=9**, and then for **N=10**.

Find the area given **B=6**, and **N=10, 100, 150, 1000**, and **10000**. Compare your results with $\pi 6^2$ (the area of a circle with radius 6), which is approximately 113.097.

7. Enter **B=6**. To find the area **A**, move the cursor onto **A**, and then press **[ALPHA] [SOLVE]**. Find **A** for **N=10**, then **N=100**, then **N=150**, then **N=1000**, and finally **N=10000**. Notice that as **N** gets large, the area **A** approaches πB^2 .

Now graph the equation to see visually how the area changes as the number of sides gets large.

8. Press **[MODE]**. Select the default mode settings.

9. Press **[WINDOW]**. Set the viewing window.

Xmin=0

Ymin=0

Xres=1

Xmax=200

Ymax=150

Xscl=10

Yscl=10

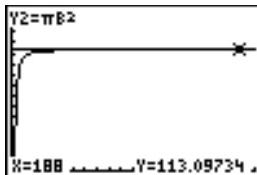
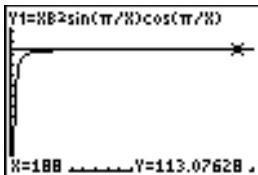
10. Press **[Y=]**. Turn off all functions and stat plots. Enter the equation for the area. Use **X** in place of **N**. Set the graph styles as shown.

```

Plot1 Plot2 Plot3
Y1=XB^2sin(pi/X)cos(pi/X)
Y2=piB^2
Y3=
Y4=
Y5=
Y6=

```

11. Press **TRACE**. After the graph is plotted, press **100 ENTER** to trace to **X=100**. Press **150 ENTER**. Press **188 ENTER**. Notice that as X increases, the value of Y converges to πB^2 , which is approximately 113.097. $Y2=\pi B^2$ (the area of the circle) is a horizontal asymptote to $Y1$. The area of an N-sided regular polygon, with r as the distance from the center to a vertex, approaches the area of a circle with radius r (πr^2) as N gets large.



Computing and Graphing Mortgage Payments

Problem

You are a loan officer at a mortgage company, and you recently closed on a 30-year home mortgage at 8 percent interest with monthly payments of 800. The new home owners want to know how much will be applied to the interest and how much will be applied to the principal when they make the 240th payment 20 years from now.

Procedure

1. Press **MODE** and set the fixed-decimal mode to 2 decimal places. Set the other mode settings to the defaults.
2. Press **APPS** **ENTER** **ENTER** to display the **TVM Solver**. Enter these values.

```
N=360.00  
I%=-8.00  
PV=0.00  
PMT=-800.00  
FV=0.00  
P/Y=12.00  
C/Y=12.00  
PMT:=END BEGIN
```

Note: Enter a positive number (**800**) to show **PMT** as a cash inflow. Payment values will be displayed as positive numbers on the graph. Enter **0** for **FV**,

since the future value of a loan is 0 once it is paid in full. Enter **PMT: END**, since payment is due at the end of a period.

- Move the cursor onto the **PV=** prompt, and then press **[ALPHA] [SOLVE]**. The present value, or mortgage amount, of the house is displayed at the **PV=** prompt.

```
N=360.00
I%=.00
■ PV=-109026.80
PMT=800.00
FV=0.00
P/Y=12.00
C/Y=12.00
PMT:END BEGIN
```

Now compare the graph of the amount of interest with the graph of the amount of principal for each payment.

- Press **[MODE]**. Set **Par** and **Simul**.
- Press **[Y=]**. Turn off all functions and stat plots. Enter these equations and set the graph styles as shown.

```
Plot1 Plot2 Plot3
X1T:BT
Y1T:ΣPrn(T,T)
X2T:BT
Y2T:ΣInt(T,T)
X3T:BT
Y3T:Y1T+Y2T
```

Note: $\Sigma\text{Prn(}$ and $\Sigma\text{Int(}$ are located on the **FINANCE** menu (**APPS 1:FINANCE**).

6. Press **WINDOW**. Set these window variables.

Tmin=1

Xmin=0

Ymin=0

Tmax=360

Xmax=360

Ymax=1000

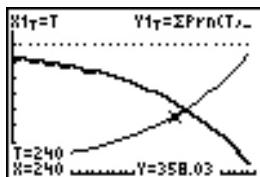
Tstep=12

Xscl=10

Yscl=100

Tip: To increase the graph speed, change **Tstep** to 24.

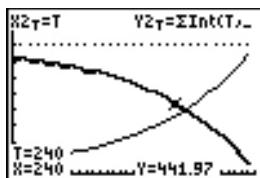
7. Press **TRACE**. After the graph is drawn, press **240** **ENTER** to move the trace cursor to **T=240**, which is equivalent to 20 years of payments.



The graph shows that for the 240th payment (**X=240**), 358.03 of the 800 payment is applied to principal (**Y=358.03**).

Note: The sum of the payments ($Y3_T=Y1_T+Y2_T$) is always 800.

8. Press **▼** to move the cursor onto the function for interest defined by $X2_T$ and $Y2_T$. Enter **240**.



The graph shows that for the 240th payment ($X=240$), 441.97 of the 800 payment is interest ($Y=441.97$).

9. Press [2nd] [QUIT] [APPS] [ENTER] 9 to paste **9:bal(** to the home screen. Check the figures from the graph.

```
bal(239)
-66295.33
Ans*(.08/12)
-441.97
```

At which monthly payment will the principal allocation surpass the interest allocation?

Chapter 18:

Memory and Variable Management

Checking Available Memory

MEMORY Menu

At any time you can check available memory or manage existing memory by selecting items from the **MEMORY** menu. To access this menu, press **[2nd] [MEM]**.

| MEMORY | |
|--------------------|---|
| 1 :About... | Displays information about the calculator. |
| 2 :Mem Mgmt/Del... | Reports memory availability and variable usage. |
| 3 :Clear Entries | Clears ENTRY (last-entry storage). |
| 4 :ClrAllLists | Clears all lists in memory. |
| 5 :Archive... | Archives a selected variable. |
| 6 :UnArchive... | UnArchives a selected variable. |
| 7 :Reset... | Displays the RAM , ARCHIVE , and ALL menus |
| 8 :Group... | Displays GROUP and UNGROUP menus. |

To check **memory usage**, first press **[2nd] [MEM]** and then press **2:Mem Mgmt/Del**.

Displaying the MEMORY MANAGEMENT/DELETE Menu

Mem Mgmt/Del displays the **MEMORY MANAGEMENT/DELETE** menu. The two lines at the top report the total amount of available **RAM** and **ARCHIVE** memory. By selecting menu items on this screen, you can see the amount of memory each variable type is using. This information can help you determine if some variables need to be deleted from memory to make room for new data, such as programs or applications.

To check memory usage, follow these steps.

1. Press **2nd [MEM]** to display the **MEMORY** menu.



Note: The ↑ and ↓ in the top or bottom of the left column indicate that you can scroll up or down to view more variable types.

2. Select **2:Mem Mgmt/Del** to display the **MEMORY MANAGEMENT/DELETE** menu. The TI-83 Plus expresses memory quantities in bytes.



3. Select variable types from the list to display memory usage.

Note: **Real**, **List**, **Y-Vars**, and **Prgm** variable types never reset to zero, even after memory is cleared.

Apps are independent applications which are stored in Flash ROM.

AppVars is a variable holder used to store variables created by independent applications. You cannot edit or change variables in **AppVars** unless you do so through the application which created them.

To leave the **MEMORY MANAGEMENT/DELETE** menu, press either **2nd [QUIT]** or **[CLEAR]**. Both options display the home screen.

Deleting Items from Memory

Deleting an Item

To increase available memory by deleting the contents of any variable (real or complex number, list, matrix, $\text{Y}=$ variable, program, Apps, AppVars, picture, graph database, or string), follow these steps.

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.
2. Select **2:Mem Mgmt/Del** to display the **MEMORY MANAGEMENT/DELETE** menu.
3. Select the type of data you want to delete, or select **1:All** for a list of all variables of all types. A screen is displayed listing each variable of the type you selected and the number of bytes each variable is using.

For example, if you select **4>List**, the **LIST** editor screen is displayed.

| | |
|----------------|-------|
| RAM FREE | 24317 |
| ARC FREE | 1540K |
| L ₁ | 12 |
| L ₂ | 12 |
| L ₃ | 12 |

4. Press **▲** and **▼** to move the selection cursor (**▶**) next to the item you want to delete, and then press **DEL**. The variable is deleted from memory. You can delete individual variables one by one from this screen.

Note: If you are deleting programs or Apps, you will receive a message asking you to confirm this delete action. Select **2:Yes** to continue.

To leave any variable screen without deleting anything, press **[2nd] [QUIT]**, which displays the home screen.

Note: You cannot delete some system variables, such as the last-answer variable **Ans** and the statistical variable **RegEQ**.

Clearing Entries and List Elements

Clear Entries

Clear Entries clears the contents of the **ENTRY** (last entry) storage area (Chapter 1). To clear the **ENTRY** storage area, follow these steps.

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.
2. Select **3:Clear Entries** to paste the instruction to the home screen.
3. Press **[ENTER]** to clear the **ENTRY** storage area.

Clear Entries
Done

To cancel **Clear Entries**, press **[CLEAR]**.

Note: If you select **3:Clear Entries** from within a program, the **Clear Entries** instruction is pasted to the program editor, and the **Entry** (last entry) is cleared when the program is executed.

ClrAllLists

ClrAllLists sets the dimension of each list in RAM only to **0**.

To clear all elements from all lists, follow these steps.

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.
2. Select **4:ClrAllLists** to paste the instruction to the home screen.
3. Press **[ENTER]** to set to **0** the dimension of each list in memory.

ClrAllLists **Done**

To cancel **ClrAllLists**, press **[CLEAR]**.

ClrAllLists does not delete list names from memory, from the **LIST NAMES** menu, or from the stat list editor.

Note: If you select **4:ClrAllLists** from within a program, the **ClrAllLists** instruction is pasted to the program editor. The lists are cleared when the program is executed.

Resetting the TI-83 Plus

RAM ARCHIVE ALL Menu

The **RAM ARCHIVE ALL** menu gives you the option of resetting all memory (including default settings) or resetting selected portions of memory while preserving other data stored in memory, such as programs and **Y=** functions. For instance, you can choose to reset all of RAM or just restore the default settings. Be aware that if you choose to reset RAM, all data and programs in RAM will be erased. For archive memory, you can reset variables (Vars), applications (Apps), or both of these. Be aware that if you choose to reset Vars, all data and programs in archive memory will be erased. If you choose to reset Apps, all applications in archive memory will be erased.

When you reset defaults on the TI-83 Plus, all defaults in RAM are restored to the factory settings. Stored data and programs are not changed.

These are some examples of TI-83 Plus defaults that are restored by resetting the defaults.

- Mode settings such as **Normal** (notation); **Func** (graphing); **Real** (numbers); and **Full** (screen)
- **Y=** functions off

- Window variable values such as **Xmin=-10; Xmax=10; Xscl=1; Yscl=1;** and **Xres=1**
- Stat plots off
- Format settings such as **CoordOn** (graphing coordinates on); **AxesOn**; and **ExprOn** (expression on)
- **rand** seed value to 0

Displaying the RAM ARCHIVE ALL Menu

To display the **RAM ARCHIVE ALL** menu on the TI-83 Plus, follow these steps.

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.
2. Select **7:Reset** to display the **RAM ARCHIVE ALL** menu.



Resetting RAM Memory

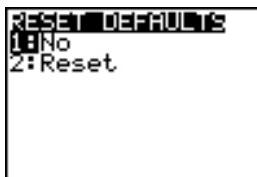
Resetting RAM restores RAM system variables to factory settings and deletes all nonsystem variables and all programs. Resetting defaults restores all system variables to default settings without deleting variables

and programs in RAM. Resetting RAM or resetting defaults does not affect variables and applications in user data archive.

Tip: Before you reset all RAM memory, consider restoring sufficient available memory by deleting only selected data.

To reset all **RAM** memory or **RAM** defaults on the TI-83 Plus, follow these steps.

1. From the **RAM ARCHIVE ALL** menu, select **1:ALL RAM** to display the **RESET RAM** menu or **2:Defaults** to display the **RESET DEFAULTS** menu.



2. If you are resetting RAM, read the message below the **RESET RAM** menu.
 - To cancel the reset and return to the home screen, press **ENTER**.
 - To erase RAM memory or reset defaults, select **2:Reset**. Depending on your choice, the message **RAM cleared** or **Defaults set** is displayed on the home screen.

Resetting Archive Memory

When resetting archive memory on the TI-83 Plus, you can choose to delete from user data archive all variables, all applications, or both variables and applications.

To reset all or part of user data archive memory, follow these steps.

1. From the **RAM ARCHIVE ALL** menu, press ▶ to display the **ARCHIVE** menu.



2. Select one of the following:

1:Vars to display the **RESET ARC VAR** menu



2:Apps to display the **RESET ARC APPS** menu.



3:Both to display the **RESET ARC BOTH** menu.



3. Read the message below the menu.

- To cancel the reset and return to the home screen, press **ENTER**.
- To continue with the reset, select **2:Reset**. A message indicating the type of archive memory cleared will be displayed on the home screen.

Resetting All Memory

When resetting all memory on the TI-83 Plus, RAM and user data archive memory is restored to factory settings. All nonsystem variables, applications, and programs are deleted. All system variables are reset to default settings.

Tip: Before you reset all memory, consider restoring sufficient available memory by deleting only selected data.

To reset all memory on the TI-83 Plus, follow these steps.

1. From the **RAM ARCHIVE ALL** menu, press **► ►** to display the **ALL** menu.



2. Select **1:All Memory** to display the **RESET MEMORY** menu.



3. Read the message below the **RESET MEMORY** menu.
 - To cancel the reset and return to the home screen, press **[ENTER]**.
 - To continue with the reset, select **2:Reset**. The message **MEM cleared** is displayed on the home screen.

Note: When you clear memory, the contrast sometimes changes. If the screen is faded or blank, adjust the contrast by pressing **[2nd] ▲** or **▼**.

Archiving and UnArchiving Variables

Archiving and UnArchiving Variables

Archiving allows you to store data, programs, or other variables to the user data archive where they cannot be edited or deleted inadvertently. Archiving also allows you to free up RAM for variables that may require additional memory.

Archived variables cannot be edited or executed. They can only be seen and unarchived. For example, if you archive list **L1**, you will see that **L1** exists in memory but if you select it and paste the name **L1** to the home screen, you won't be able to see its contents or edit it.

Note: Not all variables may be archived. Not all archived variables may be unarchived. For example, system variables including r , t , x , y , and θ cannot be archived. Apps and Groups always exist in Flash ROM so there is no need to archive them. Groups cannot be unarchived. However, you can ungroup or delete them.

| Variable Type | Names | Archive? (yes/no) | UnArchive? (yes/no) |
|----------------------|---|----------------------|------------------------|
| Real numbers | A, B, ... , Z | yes | yes |
| Complex numbers | A, B, ... , Z | yes | yes |
| Matrices | [A], [B], [C], ... , [J] | yes | yes |
| Lists | L1, L2, L3, L4, L5, L6, and user-defined names | yes | yes |
| Programs | | yes | yes |
| Functions | Y1, Y2, . . . , Y9, Y0 | no | not applicable |
| Parametric equations | X1T and Y1T, . . . , X6T and Y6T | no | not applicable |
| Polar functions | r1, r2, r3, r4, r5, r6 | no | not applicable |
| Sequence functions | u, v, w | no | not applicable |
| Stat plots | Plot1, Plot2, Plot3 | no | not applicable |
| Graph databases | GDB1, GDB2,... | yes | yes |
| Graph pictures | Pic1, Pic2, . . . , Pic9, Pic0 | yes | yes |
| Strings | Str1, Str2, . . . Str9, Str0 | yes | yes |

| Variable Type | Names | Archive? (yes/no) | UnArchive? (yes/no) |
|-------------------------------|---|----------------------|------------------------|
| Tables | TblStart , Tb1 , TblInput | no | not applicable |
| Apps | Applications | see Note above | no |
| AppVars | Application variables | yes | yes |
| Groups | | see Note above | no |
| Variables with reserved names | minX , maxX , RegEQ , and others | no | not applicable |
| System variables | Xmin , Xmax , and others | no | not applicable |

Archiving and unarchiving can be done in two ways:

- Use the **5:Archive** or **6:UnArchive** commands from the **MEMORY** menu or **CATALOG**.
- Use a Memory Management editor screen.

Before archiving or unarchiving variables, particularly those with a large byte size (such as large programs) use the **MEMORY** menu to:

- Find the size of the variable.
- See if there is enough free space.

| For: | Sizes must be such that: |
|-----------|-----------------------------------|
| Archive | Archive free size > variable size |
| UnArchive | RAM free size > variable size |

Note: If there is not enough space, unarchive or delete variables as necessary. Be aware that when you unarchive a variable, not all the memory associated with that variable in user data archive will be released since the system keeps track of where the variable has been and where it is now in RAM.

Even if there appears to be enough free space, you may see a Garbage Collection message when you attempt to archive a variable. Depending on the usability of empty blocks in the user data archive, you may need to unarchive existing variables to create more free space.

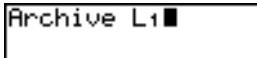
To archive or unarchive a list variable (L1) using the Archive/UnArchive options from the MEMORY menu:

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.



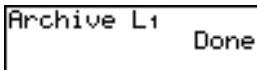
2. Select **5:Archive** or **6:UnArchive** to place the command in the edit screen.

3. Press **[2nd] [L1]** to place the L1 variable in the edit screen.



Archive L1

4. Press **[ENTER]** to complete the archive process.



Archive L1 Done

Note: An asterisk will be displayed to the left of the Archived variable name to indicate it is archived.

To archive or unarchive a list variable (L1) using a Memory Management editor:

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.



MEMORY
1:About
2:Mem Mgmt/Del...
3:Clear Entries
4:ClrAllLists
5:Archive
6:UnArchive
7↓Reset...

2. Select **2:Mem Mgmt/Del...** to display the **MEMORY MANAGEMENT/DELETE** menu.

| |
|-----------------|
| RAM FREE 23896 |
| ARC FREE 868260 |
| ►A11... |
| 2:Real... |
| 3:Complex... |
| 4>List... |
| 5:Matrix... |
| 6+Y-Vars... |

3. Select 4:**List...** to display the **LIST** menu.

| |
|---------------------|
| RAM FREE 23896 |
| ARC FREE 868260 |
| ► L ₁ 12 |
| L ₂ 12 |
| L ₃ 12 |
| L ₄ 12 |
| L ₅ 12 |
| L ₆ 12 |

4. Press **[ENTER]** to archive L₁. An asterisk will appear to the left of L₁ to indicate it is an archived variable. To unarchive a variable in this screen, put the cursor next to the archived variable and press **[ENTER]**. The asterisk will disappear.

| |
|---------------------|
| RAM FREE 23894 |
| ARC FREE 868235 |
| ►*L ₁ 12 |
| L ₂ 12 |
| L ₃ 12 |
| L ₄ 12 |
| L ₅ 12 |
| L ₆ 12 |

5. Press **[2nd] [QUIT]** to leave the **LIST** menu.

Note: You can access an archived variable for the purpose of linking, deleting, or unarchiving it, but you cannot edit it.

Grouping and Ungrouping Variables

Grouping Variables

Grouping allows you to make a copy of two or more variables residing in RAM and then store them as a group in user data archive. The variables in RAM are not erased. The variables must exist in RAM before they can be grouped. In other words, archived data cannot be included in a group.

To create a group of variables:

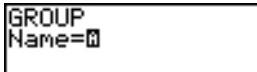
1. Press **2nd [MEM]** to display the **MEMORY** menu.



2. Select **8:Group...** to display **GROUP UNGROUP** menu.



3. Press **[ENTER]** to display the **GROUP** menu.



4. Enter a name for the new group and press **[ENTER]**.

Note: A group name can be one to eight characters long. The first character must be a letter from A to Z or θ. The second through eighth characters can be letters, numbers, or θ.



5. Select the type of data you want to group. You can select **1>All+** which shows all variables of all types available and selected. You can also select **1>All-** which shows all variables of all types available but not selected. A screen is displayed listing each variable of the type you selected.



For example, suppose some variables have been created in RAM, and selecting **1>All-** displays the following screen.

```
SELECT Done
▶ PROGRAM1 PRGM
PROGRAM2 PRGM
GDB1 GDB
L1 LIST
L2 LIST
L3 LIST
L4 LIST
```

6. Press **◀** and **▼** to move the selection cursor (**▶**) next to the first item you want to copy into a group, and then press **ENTER**. A small square will remain to the left of all variables selected for grouping.

```
SELECT Done
PROGRAM1 PRGM
▪ PROGRAM2 PRGM
▪ GDB1 GDB
▪ L1 LIST
▪ L2 LIST
▶ L3 LIST
L4 LIST
```

Repeat the selection process until all variables for the new group are selected and then press **▶** to display the **DONE** menu.

```
SELECT DONE
Done
```

7. Press **ENTER** to complete the grouping process.

```
Copying
Variables to
Group:
GROUPA
Done
```

Note: You can only group variables in RAM. You cannot group some system variables, such as the last-answer variable **Ans** and the statistical variable **RegEQ**.

Ungrouping Variables

Ungrouping allows you to make a copy of variables in a group stored in user data archive and place them ungrouped in **RAM**.

DuplicateName Menu

During the ungrouping action, if a duplicate variable name is detected in RAM, the **DUPLICATE NAME** menu is displayed.

DuplicateName

- | | |
|-----------------|---|
| 1:Rename | Prompts to rename receiving variable. |
| 2:Overwrite | Overwrites data in receiving duplicate variable. |
| 3:Overwrite All | Overwrites data in all receiving duplicate variables. |
| 4:0mit | Skips transmission of sending variable. |
| 5:Quit | Stops transmission at duplicate variable. |
-

Notes about Menu Items:

- When you select **1:Rename**, the **Name=** prompt is displayed, and alpha-lock is on. Enter a new variable name, and then press **ENTER**. Ungrouping resumes.

- When you select **2:Overwrite**, the unit overwrites the data of the duplicate variable name found in RAM. Ungrouping resumes.
- When you select **3: Overwrite All**, the unit overwrites the data of all duplicate variable names found in RAM. Ungrouping resumes.
- When you select **4:Omit**, the unit does not ungroup the variable in conflict with the duplicated variable name found in RAM. Ungrouping resumes with the next item.
- When you select **5:Quit**, ungrouping stops, and no further changes are made.

To ungroup a group of variables:

1. Press **[2nd] [MEM]** to display the **MEMORY** menu.



2. Select **8:Group...** to display the **GROUP UNGROUP** menu.
3. Press **[▶]** to display the **UNGROUP** menu.

```
GROUP UNGROUP  
1:*GROUP1  
2:*GROUPA  
3:*GROUPC
```

4. Press **▲** and **▼** to move the selection cursor (**►**) next to the group variable you want to ungroup, and then press **ENTER**.

```
Ungrouping:  
GROUP1
```

Done

The ungroup action is completed.

Note: Ungrouping does not remove the group from user data archive. You must delete the group in user data archive to remove it.

Garbage Collection

Garbage Collection Message

If you use the user data archive extensively, you may see a **Garbage Collect?** message. This occurs if you try to archive a variable when there is not enough free contiguous archive memory. The TI-83 Plus will attempt to rearrange the archived variables to make additional room.

Responding to the Garbage Collection Message

- To cancel, select 1:**No**.
- If you choose 1:**No**, the message **ERR:ARCHIVE FULL** will be displayed.
- To continue archiving, select 2:**Yes**.



If you select 2:**Yes**, the process message **Garbage Collecting...** or **Defragmenting...** will be displayed.

Note: The process message **Defragmenting...** is displayed whenever an application marked for deletion is encountered.

Garbage collection may take up to 20 minutes, depending on how much of archive memory has been used to store variables.

After garbage collection, depending on how much additional space is freed, the variable may or may not be archived. If not, you can unarchive some variables and try again.

Why Not Perform Garbage Collection Automatically Without a Message?

The message:

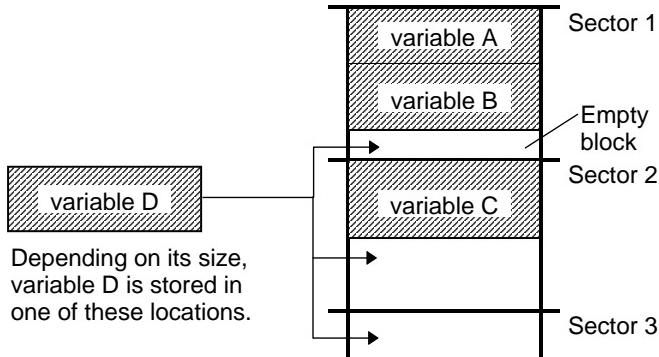
- Lets you know an archive will take longer than usual. It also alerts you that the archive will fail if there is not enough memory.
- Can alert you when a program is caught in a loop that repetitively fills the user data archive. Cancel the archive and determine the reason.

Why Is Garbage Collection Necessary?

The user data archive is divided into sectors. When you first begin archiving, variables are stored consecutively in sector 1. This continues to the end of the sector.

An archived variable is stored in a continuous block within a single sector. Unlike an application stored in user data archive, an archived variable cannot cross a sector boundary. If there is not enough space left in the sector, the next variable is stored at the beginning of the next sector. Typically, this leaves an empty block at the end of the previous sector.

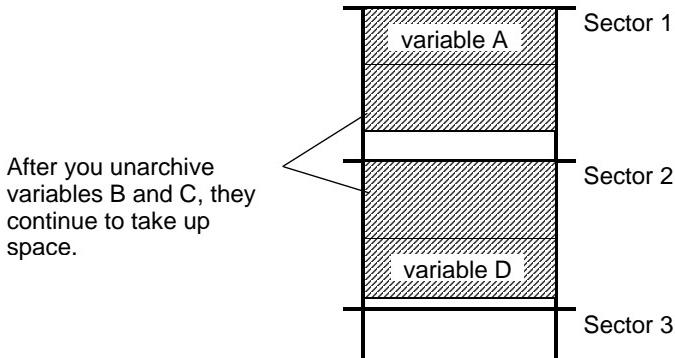
Each variable that you archive is stored in the first empty block large enough to hold it.



This process continues to the end of the last sector. Depending on the size of individual variables, the empty blocks may account for a significant amount of space. Garbage collection occurs when the variable you are archiving is larger than any empty block.

How Unarchiving a Variable Affects the Process

When you unarchive a variable, it is copied to RAM but it is not actually deleted from user data archive memory.



Unarchived variables are “marked for deletion,” meaning they will be deleted during the next garbage collection.

If the MEMORY Screen Shows Enough Free Space

Even if the **MEMORY** screen shows enough free space to archive a variable or store an application, you may still get a **Garbage Collect?** message or an **ERR: ARCHIVE FULL** message.

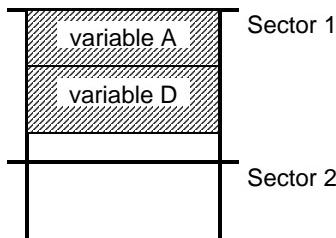
When you unarchive a variable, the **Archive free** amount increases immediately, but the space is not actually available until after the next garbage collection.

If the **Archive free** amount shows enough available space for your variable, there probably will be enough space to archive it after garbage collection (depending on the usability of any empty blocks).

The Garbage Collection Process

The garbage collection process:

- Deletes unarchived variables from the user data archive.
- Rearranges the remaining variables into consecutive blocks.



Note: Power loss during garbage collection may cause all memory (RAM and Archive) to be deleted.

Using the GarbageCollect Command

You can reduce the number of automatic garbage collections by periodically optimizing memory. This is done by using the **GarbageCollect** command.

To use the **GarbageCollect** command, follow these steps.

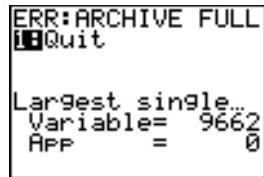
1. Press **2nd [CATALOG]** to display the **CATALOG**.



2. Press **▼** or **▲** to scroll the **CATALOG** until the selection cursor points to the **GarbageCollect** command.
3. Press **[ENTER]** to paste the command to the current screen.
4. Press **[ENTER]** to display the **Garbage Collect?** message.
5. Select **2:Yes** to begin garbage collection.

ERR:ARCHIVE FULL Message

Even if the **MEMORY** screen shows enough free space to archive a variable or store an application, you may still get an **ERR: ARCHIVE FULL** message.



An **ERR:ARCHIVE FULL** message may be displayed:

- When there is insufficient space to archive a variable within a continuous block and within a single sector.
- When there is insufficient space to store an application within a continuous block of memory.

When the message is displayed, it will indicate the largest single space of memory available for storing a variable and an application.

To resolve the problem, use the **GarbageCollect** command to optimize memory. If memory is still insufficient, you must delete variables or applications to increase space.

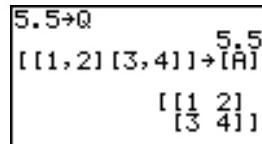
Chapter 19: **Communication Link**

Getting Started: Sending Variables

Getting Started is a fast-paced introduction. Read the chapter for details.

Create and store a variable and a matrix, and then transfer them to another TI-83 Plus.

1. On the home screen of the sending unit, press **5** **[STO►]** **[ALPHA]** **Q**. Press **[ENTER]** to store 5.5 to **Q**.
2. Press **[2nd]** **[]** **[2nd]** **[]** **1** **,** **2** **[2nd]** **[]** **[2nd]** **[]** **3** **,** **4** **[2nd]** **[]** **[2nd]** **[]** **[STO►]** **[2nd]** **[MATRIX]** **1**. Press **[ENTER]** to store the matrix to **[A]**.
3. On the sending unit, press **[2nd]** **[MEM]** to display the **MEMORY** menu.



5.5→Q
[[1,2][3,4]]→[A]
[[1 2]
[3 4]]



MEMORY
1:About
2:Mem Mgmt/Del...
3:Clear Entries
4:ClrAllLists
5:Archive
6:UnArchive
7:Reset...

4. On the sending unit, press **2** to select **2:Mem Mgmt/Del**. The **MEMORY MANAGEMENT** menu is displayed.

```
RAM FREE 23896
ARC FREE 868260
1:All...
2:Real...
3:Complex...
4>List...
5:Matrix...
6↓Y-Vars...
```

5. On the sending unit, press **5** to select **5:Matrix**. The **MATRIX** editor screen is displayed.

```
RAM FREE 23896
ARC FREE 868260
► [A] 47
```

6. On the sending unit, press **[ENTER]** to archive **[A]**. An asterisk (*) will appear, signifying that **[A]** is now archived.

```
RAM FREE 23934
ARC FREE 868210
►*[A] 47
```

7. Connect the calculators with the link cable. Push both ends in firmly.

8. On the receiving unit, press **2nd [LINK] ▶** to display the **RECEIVE** menu. Press **1** to select **1:Receive**. The message **Waiting...** is displayed and the busy indicator is on.

```
SEND RECEIVE
1:Receive
```

9. On the sending unit, press **2nd [LINK]** to display the **SEND** menu.

```
SEND RECEIVE
1:All+...
2:All...
3:Prgm...
4>List...
5:Lists to TI82...
6:GDB...
7↓Pic...
```

10. Press **2** to select **2:All-**. The **All- SELECT** screen is displayed.

11. Press until the selection cursor (►) is next to [A] MATRX. Press **[ENTER]**.
12. Press until the selection cursor is next to Q REAL. Press **[ENTER]**. A square dot next to [A] and Q indicates that each is selected to send.
13. On the sending unit, press ► to display the TRANSMIT menu.
14. On the sending unit, press 1 to select 1:Transmit and begin transmission. The receiving unit displays the message Receiving....When the items are transmitted, both units display the name and type of each transmitted variable.

SELECT TRANSMIT

| | |
|-----------|--------|
| *[A] | MATRX |
| Y1 | EQU |
| Y2 | EQU |
| Window | WINDOW |
| Rc1Window | ZSTO |
| TblSet | TABLE |
| Q | REAL |

SELECT TRANSMIT

| |
|------------|
| 1:Transmit |
|------------|

Receiving...

| | |
|------|-------|
| *[A] | MATRX |
| Q | REAL |
| Done | |

TI-83 Plus Silver Edition LINK

This chapter describes how to communicate with compatible TI units. A unit-to-unit link cable is included with the TI-83 Plus Silver Edition for this purpose.

The TI-83 Plus Silver Edition has a port to connect and communicate with:

- Another TI-83 Plus Silver Edition
- A TI-83 Plus
- A TI-83
- A TI-82
- A TI-73
- A CBL 2/CBL, or a CBR

With the **TI™ Connect** or **TI-GRAFH LINK™** software and a **TI-GRAFH LINK** cable, you can link the TI-83 Plus Silver Edition to a personal computer.

Connecting Two Calculators with a Unit-to-Unit Cable

The TI-83 Plus link port is located at the center of the bottom edge of the calculator.

1. Firmly insert either end of the unit-to-unit cable into the port.
2. Insert the other end of the cable into the other calculator's port.

Linking to the CBL/CBR System

The CBL 2/CBL and the CBR are optional accessories that also connect to a TI-83 Plus with the unit-to-unit link cable. With a CBL 2/CBL or CBR and a TI-83 Plus, you can collect and analyze real-world data. The software that enables this communication is built into the TI-83 Plus. (Chapter 14).

Linking to a Computer

TI-GRAF LINK™ is an accessory that links a TI-83 Plus to enable communication with a computer. A Macintosh®-compatible **TI-GRAF LINK** is available separately.

You can access **TI-GRAF LINK** guidebooks through
education.ti.com/guides.

Selecting Items to Send

LINK SEND Menu

To display the **LINK SEND** menu, press **[2nd] [LINK]**.

| SEND | RECEIVE |
|--------------------|---|
| 1:All+... | Displays all items as selected, including RAM and Flash applications. |
| 2:All--- | Displays all items as deselected. |
| 3:Prgm... | Displays all program names. |
| 4>List... | Displays all list names. |
| 5:Lists to TI82... | Displays list names L1 through L6 . |
| 6:GDB... | Displays all graph databases. |
| 7:Pic... | Displays all picture data types. |
| 8:Matrix... | Displays all matrix data types. |
| 9:Real... | Displays all real variables. |
| 0:Complex... | Displays all complex variables. |
| A:Y-Vars... | Displays all Y= variables. |
| B:String... | Displays all string variables. |
| C:Apps... | Displays all software applications. |
| D:AppVars... | Displays all software application variables. |
| E:Group... | Displays all grouped variables. |
| F:SendId | Sends the Calculator ID number immediately. (You do not need to select SEND .) |

SEND RECEIVE

G:SendOS

Sends operating system updates to another TI-83 Plus Silver Edition or TI-83 Plus.

H:Back Up...

Selects all RAM and mode settings (no Flash applications or archived items) for backup to another TI-83 Plus Silver Edition or to a TI-83 Plus.

When you select an item on the **LINK SEND** menu, the corresponding **SELECT** screen is displayed.

Note: Each **SELECT** screen, except **All+...**, is initially displayed with nothing pre-selected. **All+...** is displayed with everything pre-selected.

To select items to send:

1. Press **[2nd] [LINK]** on the sending unit to display the **LINK SEND** menu.
2. Select the menu item that describes the data type to send. The corresponding **SELECT** screen is displayed.
3. Press **▲** and **▼** to move the selection cursor (**▶**) to an item you want to select or deselect.

4. Press **[ENTER]** to select or deselect the item. Selected names are marked with a ■.

| SELECT TRANSMIT | |
|-------------------|------|
| ■ *PROGRAM1 | PRGM |
| PROGRAM2 | PRGM |
| ■ *GDB1 | GDB |
| ■ L ₁ | LIST |
| ■ *L ₂ | LIST |
| ■ *L ₃ | LIST |
| ► L ₄ | LIST |

Note: An asterisk (*) to the left of an item indicates the item is archived (Chapter 18).

5. Repeat steps 3 and 4 to select or deselect additional items.

Sending the Selected Items

After you have selected items to send on the sending unit and set the receiving unit to receive, follow these steps to transmit the items. To set the receiving unit, see [Receiving Items](#).

1. Press **[□]** on the sending unit to display the **TRANSMIT** menu.

| SELECT TRANSMIT | |
|-----------------|--|
| ► Transmit | |

2. Confirm that **Waiting...** is displayed on the receiving unit, which indicates it is set to receive.

3. Press **[ENTER]** to select **1:Transmit**. The name and type of each item are displayed line-by-line on the sending unit as the item is queued for transmission, and then on the receiving unit as each item is accepted.

| | |
|-----------------------|-----------------------|
| *PROGRAM1 PRGM | Receiving... |
| *GDB1 GDB | *PROGRAM1 PRGM |
| L ₁ LIST | *GDB1 GDB |
| *L ₂ LIST | L ₁ LIST |
| ►*L ₃ LIST | *L ₂ LIST |
| Done | ►*L ₃ LIST |
| | Done |

Note: Items sent from the RAM of the sending unit are transmitted to the RAM of the receiving unit. Items sent from user data archive of the sending unit are transmitted to user data archive of the receiving unit.

After all selected items have been transmitted, the message **Done** is displayed on both calculators. Press **▲** and **▼** to scroll through the names.

Stopping a Transmission

To stop a link transmission, press **[ON]**. The **Error in Xmit** menu is displayed on both units. To leave the error menu, select **1:Quit**.

Sending to a TI-83 Plus Silver Edition or TI-83 Plus

You can transfer variables (all types), programs, and Flash applications to another TI-83 Plus Silver Edition or TI-83 Plus. You can also backup the RAM memory of one unit to another.

Note: Keep in mind that the TI-83 Plus has less Flash memory than the TI-83 Plus Silver Edition.

- Variables stored in RAM on the sending TI-83 Plus Silver Edition will be sent to the RAM of the receiving TI-83 Plus Silver Edition or TI-83 Plus.
- Variables and applications stored in the user data archive of the sending TI-83 Plus Silver Edition will be sent to the user data archive of the receiving TI-83 Plus Silver Edition or TI-83 Plus.

After sending or receiving data, you can repeat the same transmission to additional TI-83 Plus Silver Edition or TI-83 Plus units—from either the sending unit or the receiving unit—without having to reselect data to send. The current items remain selected. However, you cannot repeat transmission if you selected All+ or All-.

To send data to an additional TI-83 Plus Silver Edition or a TI-83 Plus:

1. Use a unit-to-unit cable to link two units together.
2. On the sending unit press **[2nd] [LINK]** and select a data type and items to **SEND**.
3. Press **[▶]** on the sending unit to display the **TRANSMIT** menu.
4. On the other unit, press **[2nd] [LINK] [▶]** to display the **RECEIVE** menu.
5. Press **[ENTER]** on the receiving unit.
6. Press **[ENTER]** on the sending unit. A copy of the selected item(s) is sent to the receiving unit.
7. Disconnect the link cable only from the receiving unit and connect it to another unit.
8. Press **[2nd] [LINK]** on the sending unit.
9. Select only the data type. For example, if the unit just sent a list, select **4:LIST**.

Note: The item(s) you want to send are pre-selected from the last transmission. Do not select or deselect any items. If you select or deselect

an item, all selections or deselections from the last transmission are cleared.

10. Press **►** on the sending unit to display the **TRANSMIT** menu.
11. On the new receiving unit, press **[2nd] [LINK] ►** to display the **RECEIVE** menu.
12. Press **[ENTER]** on the receiving unit.
13. Press **[ENTER]** on the sending unit. A copy of the selected item(s) is sent to the receiving unit.
14. Repeat steps 7 through 13 until the items are sent to all additional units.

Sending to a TI-83

You can send all variables from a TI-83 Plus to a TI-83 *except* Flash applications, application variables, grouped variables, new variable types, or programs with new features in them (such as **Archive**, **UnArchive**, **Asm(**, **AsmComp**, and **AsmPrgm**).

If archived variables on the TI-83 Plus are variable types recognized and used on the TI-83, you can send these variables to the TI-83. They will be automatically sent to the RAM of the TI-83 during the transfer process.

Note: You cannot perform a RAM memory backup from a TI-83 Plus to a TI-83 or from a TI-83 to a TI-83 Plus.

To send data to a TI-83:

1. Use a unit-to-unit cable to link the two units together.
2. Set the TI-83 to receive.
3. Press **[2nd] [LINK]** on the sending TI-83 Plus to display the **LINK SEND** menu.
4. Select the menu of the items you want to transmit.
5. Press **[▶]** on the sending TI-83 Plus to display the **LINK TRANSMIT** menu.
6. Confirm that the receiving unit is set to receive.
7. Press **[ENTER]** on the sending TI-83 Plus to select **1:Transmit** and begin transmitting.

Sending Lists to a TI-82

The only data type you can transmit from a TI-83 Plus to a TI-82 is real list data stored in **L1** through **L6** (with up to 99 elements for each list). If dimension is greater than 99 for a TI-83 Plus list that is selected to be sent, the receiving TI-82 will truncate the list at the ninety-ninth element during transmission.

Note: You cannot perform a memory backup from a TI-83 Plus to a TI-82 or from a TI-82 to a TI-83 Plus.

To send lists to a TI-82:

1. Use a unit-to-unit cable to link the two units together.
2. Set the TI-82 to receive.
3. Press **[2nd] [LINK]** **5** on the sending TI-83 Plus to select **5:Lists to TI82**.
The **SELECT** screen is displayed.
4. Select each list to transmit.
5. Press **[▶]** to display the **LINK TRANSMIT** menu.
6. Confirm that the receiving unit is set to receive.
7. Press **[ENTER]** to select **1:Transmit** and begin transmitting.

Sending to a TI-73

You can send real numbers, pics, real lists **L1** through **L6**, and named lists from a TI-73 to a TI-83 Plus or from a TI-83 Plus to a TI-73.

Since the Theta symbol (θ) is not recognized by the TI-73, you cannot include this symbol in any list names sent to the TI-73.

Note: You cannot perform a RAM memory backup from a TI-83 Plus to a TI-73 or from a to a TI-73 to a TI-83 Plus.

To transmit data to a TI-73:

1. Use a unit-to-unit cable to link two units together.
2. Set the TI-73 to receive.
3. Press **[2nd] [LINK] 2** on the sending TI-83 Plus to select **2:All-....** The **SELECT** screen is displayed.
4. Select items you want to send.
5. Press **[▶]** on the sending TI-83 Plus to display the **LINK TRANSMIT** menu.
6. Confirm that the receiving unit is set to receive.
7. Press **[ENTER]** on the sending TI-83 Plus to select **1:Transmit** and begin transmitting.

Receiving Items

LINK RECEIVE Menu

To display the **LINK RECEIVE** menu, press **[2nd] [LINK] ▶**.

SEND RECEIVE

1:Receive Sets unit to receive data transmission.

Receiving Unit

When you select **1:Receive** from the **LINK RECEIVE** menu on the receiving unit, the message **Waiting...** and the busy indicator are displayed. The receiving unit is ready to receive transmitted items. To exit the receive mode without receiving items, press **[ON]**, and then select **1:Quit** from the **Error in Xmit** menu.

When transmission is complete, the unit exits the receive mode. You can select **1:Receive** again to receive more items. The receiving unit then displays a list of items received. Press **[2nd] [QUIT]** to exit the receive mode.

DuplicateName Menu

During transmission, if a variable name is duplicated, the **DuplicateName** menu is displayed on the receiving unit.

DuplicateName

- | | |
|-------------|---|
| 1:Rename | Prompts to rename receiving variable. |
| 2:Overwrite | Overwrites data in receiving variable. |
| 3:Omit | Skips transmission of sending variable. |
| 4:Quit | Stops transmission at duplicate variable. |
-

When you select **1:Rename**, the **Name=** prompt is displayed, and alpha-lock is on. Enter a new variable name, and then press **[ENTER]**. Transmission resumes.

When you select **2:Overwrite**, the sending unit's data overwrites the existing data stored on the receiving unit. Transmission resumes.

When you select **3:Omit**, the sending unit does not send the data in the duplicated variable name. Transmission resumes with the next item.

When you select **4:Quit**, transmission stops, and the receiving unit exits receive mode.

Receiving from a TI-83 Plus Silver Edition or TI-83 Plus

The TI-83 Plus Silver Edition and the TI-83 Plus are totally compatible. Keep in mind, however, that the TI-83 Plus has less Flash memory than a TI-83 Plus Silver Edition.

Receiving from a TI-83

You can transfer all variables and programs from a TI-83 to a TI-83 Plus if they fit in the RAM of the TI-83 Plus. The RAM of the TI-83 Plus is slightly less than the RAM of the TI-83.

Receiving from a TI-82 — Resolved Differences

Generally, you can transmit items to a TI-83 Plus from a TI-82, but differences between the two products may affect some transmitted data. This table shows differences for which the software built into the TI-83 Plus automatically adjusts when a TI-83 Plus receives TI-82 data.

| TI-82 | TI-83 Plus |
|----------------|-----------------------|
| <i>nMin</i> | PlotStart |
| <i>nStart</i> | <i>nMin</i> |
| <i>Un</i> | u |
| <i>Vn</i> | v |
| UnStart | u(<i>nMin</i>) |
| VnStart | v(<i>nMin</i>) |
| TblMin | TblStart |

For example, if you transmit a program that contains ***nStart*** on a command line from a TI-82 to a TI-83 Plus, you will see that ***nMin*** has automatically replaced ***nStart*** on the command line of the TI-83 Plus.

Note: You can transfer all real variables, pics, and programs from a TI-82 to a TI-83 Plus if they fit in the RAM of the TI-83 Plus. The RAM of the TI-83 Plus is slightly less than the RAM of the TI-82.

Receiving from a TI-82 — Unresolved Differences

The software built into the TI-83 Plus cannot resolve some differences between the TI-82 and TI-83 Plus. These differences are described below.

You must edit the transmitted data on the receiving TI-83 Plus to account for these differences. If you do not edit these differences, the TI-83 Plus will misinterpret the data.

- The TI-83 Plus reinterprets TI-82 prefix functions to include open parentheses, which may add extraneous parentheses to transmitted expressions.

For example, if you transmit **sin X+5** from a TI-82 to a TI-83 Plus, the TI-83 Plus reinterprets it as **sin(X+5)**. Without a closing parenthesis after X, the TI-83 Plus interprets this as **sin(X+5)**, not the sum of 5 and **sin(X)**.

- If a TI-82 transmits an instruction that the TI-83 Plus cannot translate, the **ERR:INVALID** menu displays when the TI-83 Plus attempts to execute the instruction.

For example, on the TI-82, the character group **Un-1** is pasted to the cursor location when you press **2nd** [Un-1]. The TI-83 Plus cannot directly translate **Un-1** to the TI-83 Plus syntax **u(n-1)**, so the **ERR:INVALID** menu is displayed.

Note: TI-83 Plus implied multiplication rules differ from those of the TI-82. For example, the TI-83 Plus evaluates $1/2X$ as $(1/2)*X$, while the TI-82 evaluates $1/2X$ as $1/(2*X)$ (Chapter 2).

Receiving from a TI-73

The TI-83 Plus can receive real numbers, pics, real lists **L1** through **L6**, and named lists from a TI-73.

Categorical lists (lists containing alpha characters as list elements) cannot be sent from a TI-73 to a TI-83 Plus.

To transmit data to a TI-83 Plus from a TI-73:

1. Set the TI-83 Plus to receive.
2. Press **APPS** on the sending TI-73 to display the **APPLICATIONS** menu.
3. Press **ENTER** on the sending TI-73 to select **1:Link** and display the **LINK SEND** menu.
4. Choose **0:Vars to TI83**. and then select the items you want to send.

5. Press **►** on the sending TI-73 to display the **LINK TRANSMIT** menu.
6. Confirm that the receiving unit is set to receive.
7. Press **[ENTER]** on the sending TI-73 to select **1:Transmit** and begin transmitting.

Backing Up RAM Memory

Warning: **H:Back Up** overwrites the RAM memory and mode settings in the receiving unit. All information in the RAM memory of the receiving unit is lost.

Note: Archived items on the receiving unit are not overwritten.

You can backup the contents of RAM memory and mode settings (no Flash applications or archived items) to another TI-83 Plus Silver Edition. You can also backup RAM memory and mode settings to a TI-83 Plus.

To perform a RAM memory backup:

1. Use a unit-to-unit cable to link two TI-83 Plus Silver Edition units, or a TI-83 Plus Silver Edition and a TI-83 Plus together.
2. On the sending unit press **[2nd] [LINK]** and select **H:Back Up**. The **MEMORYBACKUP** screen displays.



3. On the receiving unit, press **[2nd] [LINK] ▶** to display the RECEIVE menu.
4. Press **[ENTER]** on the receiving unit.

5. Press **[ENTER]** on the sending unit. A **WARNING — Backup** message displays on the receiving unit.
 6. Press **[ENTER]** on the receiving unit to continue the backup.
— or —
Press **2:Quit** on the receiving unit to cancel the backup and return to the **LINK SEND** menu
- Note:** If a transmission error is returned during a backup, the receiving unit is reset.

Memory Backup Complete

When the backup is complete, both the sending calculator and receiving calculator display a confirmation screen.



The image shows a portion of a calculator screen with a light gray background. At the top, the text "MEMORY BACKUP" is displayed in a dark gray font. Below it, the word "Done" is centered in a smaller, dark gray font. The rest of the screen is blank white space.

Error Conditions

A transmission error occurs after one or two seconds if:

- A cable is not attached to the sending unit.
- A cable is not attached to the receiving unit.
Note: If the cable is attached, push it in firmly and try again.
- The receiving unit is not set to receive transmission.
- You attempt a backup between a TI-73, a TI-82, or a TI-83 and a TI-83 Plus.
- You attempt a data transfer from a TI-83 Plus to a TI-83, TI-82, or TI-73 with variables or features not recognized by the TI-83, TI-82, or TI-73.
- New variable types and features not recognized by the TI-83, TI-82, or TI-73 include applications, application variables, grouped variables, new variable types, or programs with new features in them such as **Archive**, **UnArchive**, **SendID**, **SendOS**, **Asm()**, **AsmComp()**, and **AsmPrgm**.
- You attempt a data transfer from a TI-83 Plus to a TI-82 with data other than real lists L₁ through L₆ or without using menu item **5:Lists to TI82**.

- You attempt a data transfer from a TI-83 Plus to a TI-73 with data other than real numbers, pics, real lists L₁ through L₆ or named lists with θ as part of the name.

Although a transmission error does not occur, these two conditions may prevent successful transmission.

- You try to use **Get(** with a calculator instead of a CBL 2/CBL or CBR.
- You try to use **GetCalc(** with a TI-83 instead of a TI-83 Plus Silver Edition or TI-83 Plus.

Insufficient Memory in Receiving Unit

During transmission, if the receiving unit does not have sufficient memory to receive an item, the **Memory Full** menu is displayed on the receiving unit.

- To skip this item for the current transmission, select **1:Omit**. Transmission resumes with the next item.
- To cancel the transmission and exit receive mode, select **2:Quit**.

Appendix A: Tables and Reference Information

Table of Functions and Instructions

Functions return a value, list, or matrix. You can use functions in an expression. Instructions initiate an action. Some functions and instructions have arguments. Optional arguments and accompanying commas are enclosed in brackets ([]). For details about an item, including argument descriptions and restrictions, turn to the page listed on the right side of the table.

From the **CATALOG**, you can paste any function or instruction to the home screen or to a command line in the program editor. However, some functions and instructions are not valid on the home screen. The items in this table appear in the same order as they appear in the **CATALOG**.

† indicates either keystrokes that are valid in the program editor only or ones that paste certain instructions when you are in the program editor. Some keystrokes display menus that are available only in the program editor. Others paste mode, format, or table-set instructions only when you are in the program editor.

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|---|
| abs(<i>value</i>) | Returns the absolute value of a real number, expression, list, or matrix. | MATH NUM 1:abs(|
| abs(<i>complex value</i>) | Returns the magnitude of a complex number or list. | MATH CPX 5:abs(|
| valueA and valueB | Returns 1 if both <i>valueA</i> and <i>valueB</i> are $\neq 0$. <i>valueA</i> and <i>valueB</i> can be real numbers, expressions, or lists. | 2nd [TEST] LOGIC 1:and |
| angle(<i>value</i>) | Returns the polar angle of a complex number or list of complex numbers. | MATH CPX 4:angle(|
| ANOVA(<i>list1</i>,<i>list2</i>, [<i>list3</i>,...,<i>list20</i>]) | Performs a one-way analysis of variance for comparing the means of two to 20 populations. | STAT TESTS F:ANOVA(|
| Ans | Returns the last answer. | 2nd [ANS] |
| Archive | Moves the specified variables from RAM to the user data archive memory. | 2nd [MEM] 5:Archive |
| Asm(<i>assemblyprgmname</i>) | Executes an assembly language program. | 2nd [CATALOG] Asm(|
| AsmComp(<i>prgmASM1</i>, <i>prgmASM2</i>) | Compiles an assembly language program written in ASCII and stores the hex version. | 2nd [CATALOG] AsmComp(|
| AsmPrgm | Must be used as the first line of an assembly language program. | 2nd [CATALOG] AsmPrgm |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|---------------------------------------|
| augment(<i>matrixA</i>, <i>matrixB</i>) | Returns a matrix, which is <i>matrixB</i> appended to <i>matrixA</i> as new columns. | [2nd] [MATRIX] MATH 7:augment(|
| augment(<i>listA</i>,<i>listB</i>) | Returns a list, which is <i>listB</i> concatenated to the end of <i>listA</i> . | [2nd] [LIST] OPS 9:augment(|
| AxesOff | Turns off the graph axes. | † [2nd] [FORMAT] AxesOff |
| AxesOn | Turns on the graph axes. | † [2nd] [FORMAT] AxesOn |
| a+bi | Sets the mode to rectangular complex number mode (a+bi). | † [MODE] a+bi |
| bal(<i>npmt</i>[,<i>roundvalue</i>]) | Computes the balance at <i>npmt</i> for an amortization schedule using stored values for PV , I% , and PMT and rounds the computation to <i>roundvalue</i> . | [APPS] 1:Finance CALC 9:bal(|
| binomcdf(<i>numtria</i>) | Computes a cumulative probability at <i>x</i> for the discrete binomial distribution with the specified <i>numtrials</i> and probability <i>p</i> of success on each trial. | [2nd] [DISTR] DISTR A:binomcdf(|
| binompdf(<i>numtrials</i>,<i>p</i>[,<i>x</i>]) | Computes a probability at <i>x</i> for the discrete binomial distribution with the specified <i>numtrials</i> and probability <i>p</i> of success on each trial. | [2nd] [DISTR] DISTR 0:binompdf(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|---|
| $\chi^2\text{cdf}(lowerbound,upperbound,df)$ | Computes the χ^2 distribution probability between <i>lowerbound</i> and <i>upperbound</i> for the specified degrees of freedom <i>df</i> . | [2nd] [DISTR] DISTR 7: $\chi^2\text{cdf}($ |
| $\chi^2\text{pdf}(x,df)$ | Computes the probability density function (pdf) for the χ^2 distribution at a specified <i>x</i> value for the specified degrees of freedom <i>df</i> . | [2nd] [DISTR] DISTR 6: $\chi^2\text{pdf}($ |
| <math>\chi^2\text{-Test}(observedmatrix, expectedmatrix [,drawflag])</math> | Performs a chi-square test. <i>drawflag=1</i> draws results; <i>drawflag=0</i> calculates results. | † [STAT] TESTS C: $\chi^2\text{-Test}($ |
| Circle(<i>X,Y,radius</i>) | Draws a circle with center (<i>X,Y</i>) and <i>radius</i> . | [2nd] [DRAW] DRAW 9:Circle(|
| Clear Entries | Clears the contents of the Last Entry storage area. | [2nd] [MEM] MEMORY 3:Clear Entries |
| ClrAllLists | Sets to 0 the dimension of all lists in memory. | [2nd] [MEM] MEMORY 4:ClrAllLists |
| ClrDraw | Clears all drawn elements from a graph or drawing. | [2nd] [DRAW] DRAW 1:ClrDraw |
| ClrHome | Clears the home screen. | † [PRGM] I/O 8:ClrHome |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|--|
| ClrList <i>listname1</i> [<i>listname2</i> , ..., <i>listname n</i>] | Sets to 0 the dimension of one or more <i>listnames</i> . | STAT EDIT 4:ClrList |
| ClrTable | Clears all values from the table. | † [PRGM] I/O 9:ClrTable |
| conj (<i>value</i>) | Returns the complex conjugate of a complex number or list of complex numbers. | [MATH] Cpx 1:conj |
| Connected | Sets connected plotting mode; resets all Y= editor graph-style settings to \wedge . | † [MODE] Connected |
| CoordOff | Turns off cursor coordinate value display. | † [2nd] [FORMAT] CoordOff |
| CoordOn | Turns on cursor coordinate value display. | † [2nd] [FORMAT] CoordOn |
| cos (<i>value</i>) | Returns cosine of a real number, expression, or list. | COS |
| cos⁻¹ (<i>value</i>) | Returns arccosine of a real number, expression, or list. | [2nd] [COS-1] |
| cosh (<i>value</i>) | Returns hyperbolic cosine of a real number, expression, or list. | [2nd] [CATALOG] cosh (|
| cosh⁻¹ (<i>value</i>) | Returns hyperbolic arccosine of a real number, expression, or list. | [2nd] [CATALOG] cosh⁻¹ (|
| CubicReg [<i>Xlistname</i> , <i>Ylistname</i> , <i>freqlist</i> , <i>regequ</i>] | Fits a cubic regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | STAT CALC 6:CubicReg |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---------------------------------------|--|---|
| cumSum(<i>list</i>) | Returns a list of the cumulative sums of the elements in <i>list</i> , starting with the first element. | [2nd] [LIST] OPS 6:cumSum(|
| cumSum(<i>matrix</i>) | Returns a matrix of the cumulative sums of <i>matrix</i> elements. Each element in the returned matrix is a cumulative sum of a <i>matrix</i> column from top to bottom. | [2nd] [MATRIX] MATH 0:cumSum(|
| dbd(<i>date1</i>,<i>date2</i>) | Calculates the number of days between <i>date1</i> and <i>date2</i> using the actual-day-count method. | [APPS] 1:Finance CALC D:dbd(|
| valueDec | Displays a real or complex number, expression, list, or matrix in decimal format. | [MATH] MATH 2:>Dec |
| Degree | Sets degree angle mode. | † [MODE] Degree |
| DelVar <i>variable</i> | Deletes from memory the contents of <i>variable</i> . | † [PRGM] CTL G:DelVar |
| DependAsk | Sets table to ask for dependent-variable values. | † [2nd] [TBLSET] Depend: Ask |
| DependAuto | Sets table to generate dependent-variable values automatically. | † [2nd] [TBLSET] Depend: Auto |
| det(<i>matrix</i>) | Returns determinant of <i>matrix</i> . | [2nd] [MATRIX] MATH 1:det(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|---|
| DiagnosticOff | Sets diagnostics-off mode; r , r² , and R² are not displayed as regression model results. | [2nd] [CATALOG] DiagnosticOff |
| DiagnosticOn | Sets diagnostics-on mode; r , r² , and R² are displayed as regression model results. | [2nd] [CATALOG] DiagnosticOn |
| dim(<i>listname</i>) | Returns the dimension of <i>listname</i> . | [2nd] [LIST] OPS 3:dim(|
| dim(<i>matrixname</i>) | Returns the dimension of <i>matrixname</i> as a list. | [2nd] [MATRIX] MATH 3:dim(|
| <i>length</i>→dim(<i>listname</i>) | Assigns a new dimension (<i>length</i>) to a new or existing <i>listname</i> . | [2nd] [LIST] OPS 3:dim(|
| {<i>rows</i>,<i>columns</i>}→ dim(<i>matrixname</i>) | Assigns new dimensions to a new or existing <i>matrixname</i> . | [2nd] [MATRIX] MATH 3:dim(|
| Disp | Displays the home screen. | † [PRGM] I/O 3:Disp |
| Disp [<i>valueA,valueB, valueC,...,value n</i>] | Displays each value. | † [PRGM] I/O 3:Disp |
| DispGraph | Displays the graph. | † [PRGM] I/O 4:DispGraph |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|-------------------------------------|
| DispTable | Displays the table. | † [PRGM] I/O 5:DispTable |
| value ►DMS | Displays <i>value</i> in DMS format. | [2nd] [ANGLE] ANGLE 4:►DMS |
| Dot | Sets dot plotting mode; resets all Y= editor graph-style settings to '...'. | † [MODE] Dot |
| DrawF <i>expression</i> | Draws <i>expression</i> (in terms of X) on the graph. | [2nd] [DRAW] DRAW 6:DrawF |
| DrawInv <i>expression</i> | Draws the inverse of <i>expression</i> by plotting X values on the y-axis and Y values on the x-axis. | [2nd] [DRAW] DRAW 8:DrawInv |
| :DS<(variable,value) :commandA :commands | Decrement <i>variable</i> by 1; skips <i>commandA</i> if <i>variable</i> < <i>value</i> . | † [PRGM] CTL B:DS<(|
| e^(power) | Returns e raised to <i>power</i> . | [2nd] [e ^x] |
| e^(list) | Returns a list of e raised to a <i>list</i> of powers. | [2nd] [e ^x] |
| Exponent: <i>value</i> E Exponent | Returns <i>value</i> times 10 to the <i>exponent</i> . | [2nd] [EE] |
| Exponent: <i>list</i> E Exponent | Returns <i>list</i> elements times 10 to the <i>exponent</i> . | [2nd] [EE] |
| Exponent: <i>matrix</i> E Exponent | Returns <i>matrix</i> elements times 10 to the <i>exponent</i> . | [2nd] [EE] |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|-------------------------------------|
| ►Eff (<i>nominal rate,</i> <i>compounding periods</i>) | Computes the effective interest rate. | [APPS] 1:Finance CALC C:►Eff(|
| Else <i>See If:Then:Else</i> | | |
| End | Identifies end of For (, If-Then-Else , Repeat , or While loop. | † [PRGM] CTL 7:End |
| Eng | Sets engineering display mode. | † [MODE] Eng |
| Equ►String (<i>Y= var,Strn</i>) | Converts the contents of a <i>Y= var</i> to a string and stores it in <i>Strn</i> . | [2nd] [CATALOG] Equ►String(|
| expr (<i>string</i>) | Converts <i>string</i> to an expression and executes it. | [2nd] [CATALOG] expr(|
| ExpReg [<i>Xlistname,</i> <i>Ylistname,freqlist,regequ</i>] | Fits an exponential regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC 0:ExpReg |
| ExprOff | Turns off the expression display during TRACE . | † [2nd] [FORMAT] ExprOff |
| ExprOn | Turns on the expression display during TRACE . | † [2nd] [FORMAT] ExprOn |
| Fcdf (<i>lowerbound,</i> <i>upperbound,</i> <i>numerator df,</i> <i>denominator df</i>) | Computes the F distribution probability between <i>lowerbound</i> and <i>upperbound</i> for the specified <i>numerator df</i> (degrees of freedom) and <i>denominator df</i> . | [2nd] [DISTR] DISTR 9:Fcdf(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|--|
| Fill (<i>value,matrixname</i>) | Stores <i>value</i> to each element in <i>matrixname</i> . | [2nd] [MATRIX] MATH 4:Fill(|
| Fill (<i>value,listname</i>) | Stores <i>value</i> to each element in <i>listname</i> . | [2nd] [LIST] OPS 4:Fill(|
| Fix # | Sets fixed-decimal mode for # of decimal places. | † [MODE] 0123456789 (select one) |
| Float | Sets floating decimal mode. | † [MODE] Float |
| fMax (<i>expression,variable, lower,upper[,tolerance]</i>) | Returns the value of <i>variable</i> where the local maximum of <i>expression</i> occurs, between <i>lower</i> and <i>upper</i> , with specified <i>tolerance</i> . | MATH MATH 7:fMax(|
| fMin (<i>expression,variable, lower,upper[,tolerance]</i>) | Returns the value of <i>variable</i> where the local minimum of <i>expression</i> occurs, between <i>lower</i> and <i>upper</i> , with specified <i>tolerance</i> . | MATH MATH 6:fMin(|
| fNInt (<i>expression,variable, lower,upper[,tolerance]</i>) | Returns the function integral of <i>expression</i> with respect to <i>variable</i> , between <i>lower</i> and <i>upper</i> , with specified <i>tolerance</i> . | MATH MATH 9:fNInt(|
| FnOff [<i>function#, function#,...,function n</i>] | Deselects all $Y=$ functions or specified $Y=$ functions. | [VARS] Y-VARS On/Off 2:FnOff |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|---|
| FnOn [<i>function#</i> , <i>function#</i> ,..., <i>function n</i>] | Selects all Y= functions or specified Y= functions. | VARS Y-VARS On/Off 1:FnOn |
| :For (<i>variable,begin,end [,increment]</i>) :commands :End :commands | Executes <i>commands</i> through End , incrementing <i>variable</i> from <i>begin</i> by <i>increment</i> until <i>variable</i> > <i>end</i> . | † PRGM CTL 4:For(|
| fPart (<i>value</i>) | Returns the fractional part or parts of a real or complex number, expression, list, or matrix. | MATH NUM 4:fPart(|
| Fpdf (<i>x,numerator df, denominator df</i>) | Computes the F distribution probability between <i>lowerbound</i> and <i>upperbound</i> for the specified <i>numerator df</i> (degrees of freedom) and <i>denominator df</i> . | 2nd [DISTR] DISTR 8:Fpdf(|
| <i>value</i> ►Frac | Displays a real or complex number, expression, list, or matrix as a fraction simplified to its simplest terms. | MATH MATH 1:►Frac |
| Full | Sets full screen mode. | † MODE Full |
| Func | Sets function graphing mode. | † MODE Func |
| GarbageCollect | Displays the garbage collection menu to allow cleanup of unused archive memory. | 2nd [CATALOG] GarbageCollect |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|--|
| gcd(<i>valueA,valueB</i>) | Returns the greatest common divisor of <i>valueA</i> and <i>valueB</i> , which can be real numbers or lists. | [MATH] NUM 9:gcd(|
| geometcdf(<i>p,x</i>) | Computes a cumulative probability at <i>x</i> , the number of the trial on which the first success occurs, for the discrete geometric distribution with the specified probability of success <i>p</i> . | [2nd] [DISTR] DISTR E:geometcdf(|
| geometpdf(<i>p,x</i>) | Computes a probability at <i>x</i> , the number of the trial on which the first success occurs, for the discrete geometric distribution with the specified probability of success <i>p</i> . | [2nd] [DISTR] DISTR D:geometpdf(|
| Get(<i>variable</i>) | Gets data from the CBL 2™/CBL™ or CBR™ System and stores it in <i>variable</i> . | † [PRGM] I/O A:Get(|
| GetCalc(<i>variable</i>) | Gets contents of <i>variable</i> on another TI-83 Plus and stores it to <i>variable</i> on the receiving TI-83 Plus. | † [PRGM] I/O 0:GetCalc(|
| getKey | Returns the key code for the current keystroke, or 0 , if no key is pressed. | † [PRGM] I/O 7:getKey |
| Goto <i>label</i> | Transfers control to <i>label</i> . | † [PRGM] CTL 0:Goto |
| GraphStyle(<i>function#, graphstyle#</i>) | Sets a <i>graphstyle</i> for <i>function#</i> . | † [PRGM] CTL H:GraphStyle(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|--|
| GridOff | Turns off grid format. | † [2nd] [FORMAT] GridOff |
| GridOn | Turns on grid format. | † [2nd] [FORMAT] GridOn |
| G-T | Sets graph-table vertical split-screen mode. | † [MODE] G-T |
| Horiz | Sets horizontal split-screen mode. | † [MODE] Horiz |
| Horizontal <i>y</i> | Draws a horizontal line at <i>y</i> . | [2nd] [DRAW] DRAW 3:Horizontal |
| identity (<i>dimension</i>) | Returns the identity matrix of <i>dimension</i> rows \times <i>dimension</i> columns. | [2nd] [MATRIX] MATH 5:identity (|
| :If <i>condition</i> :commandA :commands | If <i>condition</i> = 0 (false), skips <i>commandA</i> . | † [PRGM] CTL 1:If |
| :If <i>condition</i> :Then :commands :End :commands | Executes <i>commands</i> from Then to End if <i>condition</i> = 1 (true). | † [PRGM] CTL 2:Then |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|-------------------------------------|
| :If condition :Then :commands :Else :commands :End :commands | Executes <i>commands</i> from Then to Else if <i>condition</i> = 1 (true); from Else to End if <i>condition</i> = 0 (false). | † [PRGM] CTL 3:Else |
| imag(value) | Returns the imaginary (nonreal) part of a complex number or list of complex numbers. | [MATH] CPX 3:imag(|
| IndpntAsk | Sets table to ask for independent-variable values. | † [2nd] [TBLSET] Indpnt: Ask |
| IndpntAuto | Sets table to generate independent-variable values automatically. | † [2nd] [TBLSET] Indpnt: Auto |
| Input | Displays graph. | † [PRGM] I/O 1:Input |
| Input [variable] Input ["text",variable] | Prompts for value to store to <i>variable</i> . | † [PRGM] I/O 1:Input |
| Input [Strn,variable] | Displays Strn and stores entered value to <i>variable</i> . | † [PRGM] I/O 1:Input |
| inString(string,substring [,start]) | Returns the character position in <i>string</i> of the first character of <i>substring</i> beginning at <i>start</i> . | [2nd] [CATALOG] inString(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|---|
| int (<i>value</i>) | Returns the largest integer \leq a real or complex number, expression, list, or matrix. | MATH NUM 5:int |
| ΣInt (<i>pmt1,pmt2[,roundvalue]</i>) | Computes the sum, rounded to <i>roundvalue</i> , of the interest amount between <i>pmt1</i> and <i>pmt2</i> for an amortization schedule. | APPS 1:Finance CALC A:ΣInt(|
| invNorm (<i>area[,μ,σ]</i>) | Computes the inverse cumulative normal distribution function for a given <i>area</i> under the normal distribution curve specified by μ and σ . | 2nd [DISTR] DISTR 3:invNorm(|
| iPart (<i>value</i>) | Returns the integer part of a real or complex number, expression, list, or matrix. | MATH NUM 3:iPart(|
| irr (<i>CF0,CFList[,CFFreq]</i>) | Returns the interest rate at which the net present value of the cash flow is equal to zero. | APPS 1:Finance CALC 8:irr(|
| :IS> (<i>variable,value</i>) :commandA :commands | Increments <i>variable</i> by 1; skips <i>commandA</i> if <i>variable</i> > <i>value</i> . | † PRGM CTL A:IS>(|
| L <i>listname</i> | Identifies the next one to five characters as a user-created list name. | 2nd [LIST] OPS B:(|
| LabelOff | Turns off axes labels. | † 2nd [FORMAT] LabelOff |
| LabelOn | Turns on axes labels. | † 2nd [FORMAT] LabelOn |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|-------------------------------------|
| Lbl <i>label</i> | Creates a <i>label</i> of one or two characters. | † [PRGM] CTL 9:Lbl |
| lcm (<i>valueA,valueB</i>) | Returns the least common multiple of <i>valueA</i> and <i>valueB</i> , which can be real numbers or lists. | [MATH] NUM 8:lcm(|
| length (<i>string</i>) | Returns the number of characters in <i>string</i> . | [2nd] [CATALOG] length(|
| Line (<i>X1,Y1,X2,Y2</i>) | Draws a line from (<i>X1,Y1</i>) to (<i>X2,Y2</i>). | [2nd] [DRAW] DRAW 2:Line(|
| Line (<i>X1,Y1,X2,Y2,0</i>) | Erases a line from (<i>X1,Y1</i>) to (<i>X2,Y2</i>). | [2nd] [DRAW] DRAW 2:Line(|
| LinReg(a+bx) [<i>Xlistname, Ylistname,freqlist, regequ</i>] | Fits a linear regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC 8:LinReg(a+bx) |
| LinReg(ax+b) [<i>Xlistname, Ylistname,freqlist, regequ</i>] | Fits a linear regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC 4:LinReg(ax+b) |
| LinRegTTest [<i>Xlistname, Ylistname,freqlist, alternative,regequ</i>] | Performs a linear regression and a <i>t</i> -test. <i>alternative</i> = 1 is < ; <i>alternative</i> = 0 is # ; <i>alternative</i> = 1 is > . | † [STAT] TESTS E:LinRegTTest |
| ΔList (<i>list</i>) | Returns a list containing the differences between consecutive elements in <i>list</i> . | [2nd] [LIST] OPS 7:ΔList(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| List►matr (<i>listname</i> 1,..., <i>listname</i> n, <i>matrixname</i>) | Fills <i>matrixname</i> column by column with the elements from each specified <i>listname</i> . | 2nd [LIST] OPS 0:List►matr(|
| Ln (<i>value</i>) | Returns the natural logarithm of a real or complex number, expression, or list. | [LN] |
| LnReg [<i>Xlistname</i> , <i>Ylistname</i> , <i>freqlist</i> , <i>regequ</i>] | Fits a logarithmic regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | STAT CALC 9:LnReg |
| log (<i>value</i>) | Returns logarithm of a real or complex number, expression, or list. | [LOG] |
| Logistic [<i>Xlistname</i> , <i>Ylistname</i> , <i>freqlist</i> , <i>regequ</i>] | Fits a logistic regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | STAT CALC B:Logistic |
| Mat►list (<i>matrix</i> , <i>listnameA</i> ,..., <i>listname</i> n) | Fills each <i>listname</i> with elements from each column in <i>matrix</i> . | 2nd [LIST] OPSA:Matr►list(|
| Mat►list (<i>matrix</i> , <i>column#</i> , <i>listname</i>) | Fills a <i>listname</i> with elements from a specified <i>column#</i> in <i>matrix</i> . | 2nd [LIST] OPSA:Matr►list(|
| max (<i>valueA</i> , <i>valueB</i>) | Returns the larger of <i>valueA</i> and <i>valueB</i> . | MATH NUM 7:max(|
| max (<i>list</i>) | Returns largest real or complex element in <i>list</i> . | 2nd [LIST] MATH 2:max(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| max (listA,listB) | Returns a real or complex list of the larger of each pair of elements in listA and listB. | [2nd] [LIST] MATH 2:max(|
| max (value,list) | Returns a real or complex list of the larger of value or each list element. | [2nd] [LIST] MATH 2:max(|
| mean (list[,freqlist]) | Returns the mean of list with frequency freqlist. | [2nd] [LIST] MATH 3:mean(|
| median (list[,freqlist]) | Returns the median of list with frequency freqlist. | [2nd] [LIST] MATH 4:median(|
| Med-Med [Xlistname, Ylistname,freqlist, regequ] | Fits a median-median model to Xlistname and Ylistname with frequency freqlist, and stores the regression equation to regequ. | [STAT] CALC 3:Med-Med |
| Menu ("title","text1",label1 [,...,"text7",label7]) | Generates a menu of up to seven items during program execution. | † [PRGM] CTL C:Menu(|
| min (valueA,valueB) | Returns smaller of valueA and valueB. | [MATH] NUM 6:min(|
| min (list) | Returns smallest real or complex element in list. | [2nd] [LIST] MATH 1:min(|
| min (listA,listB) | Returns real or complex list of the smaller of each pair of elements in listA and listB. | [2nd] [LIST] MATH 1:min(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| min (<i>value, list</i>) | Returns a real or complex list of the smaller of <i>value</i> or each <i>list</i> element. | [2nd] [LIST] MATH 1:min(|
| <i>valueA</i> nCr <i>valueB</i> | Returns the number of combinations of <i>valueA</i> taken <i>valueB</i> at a time. | [MATH] PRB 3:nCr |
| <i>value</i> nCr <i>list</i> | Returns a list of the combinations of <i>value</i> taken each element in <i>list</i> at a time. | [MATH] PRB 3:nCr |
| <i>list</i> nCr <i>value</i> | Returns a list of the combinations of each element in <i>list</i> taken <i>value</i> at a time. | [MATH] PRB 3:nCr |
| <i>listA</i> nCr <i>listB</i> | Returns a list of the combinations of each element in <i>listA</i> taken each element in <i>listB</i> at a time. | [MATH] PRB 3:nCr |
| nDeriv (<i>expression, variable, value[,ε]</i>) | Returns approximate numerical derivative of <i>expression</i> with respect to <i>variable</i> at <i>value</i> , with specified ε . | [MATH] MATH 8:nDeriv(|
| ►Nom (<i>effective rate, compounding periods</i>) | Computes the nominal interest rate. | [APPS] 1:Finance CALC B:►Nom(|
| Normal | Sets normal display mode. | † [MODE] Normal |
| normalcdf (<i>lowerbound, upperbound[,μ, σ]</i>) | Computes the normal distribution probability between <i>lowerbound</i> and <i>upperbound</i> for the specified μ and σ . | [2nd] [DISTR] DISTR 2:normalcdf(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|---|
| normalpdf($x[, \mu, \sigma]$) | Computes the probability density function for the normal distribution at a specified x value for the specified μ and σ . | [2nd] [DISTR] DISTR 1:normalpdf(|
| not($value$) | Returns 0 if $value$ is $\neq 0$. $value$ can be a real number, expression, or list. | [2nd] [TEST] LOGIC 4:not(|
| $valueA \text{ nPr } valueB$ | Returns the number of permutations of $valueA$ taken $valueB$ at a time. | [MATH] PRB 2:nPr |
| $value \text{ nPr } list$ | Returns a list of the permutations of $value$ taken each element in $list$ at a time. | [MATH] PRB 2:nPr |
| $list \text{ nPr } value$ | Returns a list of the permutations of each element in $list$ taken $value$ at a time. | [MATH] PRB 2:nPr |
| $listA \text{ nPr } listB$ | Returns a list of the permutations of each element in $listA$ taken each element in $listB$ at a time. | [MATH] PRB 2:nPr |
| npv(<i>interest rate, CF0, CFList[, CFFreq]</i>) | Computes the sum of the present values for cash inflows and outflows. | [APPS] 1:Finance CALC 7:npv(|
| $valueA \text{ or } valueB$ | Returns 1 if $valueA$ or $valueB$ is $\neq 0$. $valueA$ and $valueB$ can be real numbers, expressions, or lists. | [2nd] [TEST] LOGIC 2:or |
| Output(<i>row, column, "text"</i>) | Displays <i>text</i> beginning at specified <i>row</i> and <i>column</i> . | † [PRGM] I/O 6:Output(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|--|
| Output (<i>row,column,value</i>) | Displays <i>value</i> beginning at specified <i>row</i> and <i>column</i> . | † [PRGM] I/O 6:Output(|
| Param | Sets parametric graphing mode. | † [MODE] Par |
| Pause | Suspends program execution until you press [ENTER]. | † [PRGM] CTL 8:Pause |
| Pause [<i>value</i>] | Displays <i>value</i> ; suspends program execution until you press [ENTER]. | † [PRGM] CTL 8:Pause |
| Plot# (<i>type,Xlistname,Ylistname,mark</i>) | Defines Plot# (1, 2, or 3) of <i>type Scatter</i> or <i>xyLine</i> for <i>Xlistname</i> and <i>Ylistname</i> using <i>mark</i> . | † [2nd] [STAT PLOT] PLOTS 1:Plot1- 2:Plot2- 3:Plot3- |
| Plot# (<i>type,Xlistname,freqlist</i>) | Defines Plot# (1, 2, or 3) of <i>type Histogram</i> or <i>Boxplot</i> for <i>Xlistname</i> with frequency <i>freqlist</i> . | † [2nd] [STAT PLOT] PLOTS 1:Plot1- 2:Plot2- 3:Plot3- |
| Plot# (<i>type,Xlistname,freqlist,mark</i>) | Defines Plot# (1, 2, or 3) of <i>type ModBoxplot</i> for <i>Xlistname</i> with frequency <i>freqlist</i> using <i>mark</i> . | † [2nd] [STAT PLOT] PLOTS 1:Plot1- 2:Plot2- 3:Plot3- |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| Plot#(type,datalistname, data axis,mark) | Defines Plot# (1, 2, or 3) of <i>type</i> NormProbPlot for <i>datalistname</i> on <i>data axis</i> using <i>mark</i> . <i>data axis</i> can be X or Y. | † [2nd] [STAT PLOT] PLOTS 1:Plot1- 2:Plot2- 3:Plot3- |
| PlotsOff [1,2,3] | Deselects all stat plots or one or more specified stat plots (1, 2, or 3). | [2nd] [STAT PLOT] STAT PLOTS 4:PlotsOff |
| PlotsOn [1,2,3] | Selects all stat plots or one or more specified stat plots (1, 2, or 3). | [2nd] [STAT PLOT] STAT PLOTS 5:PlotsOn |
| Pmt_Bgn | Specifies an annuity due, where payments occur at the beginning of each payment period. | [APPS] 1:Finance CALC F:Pmt_Bgn |
| Pmt_End | Specifies an ordinary annuity, where payments occur at the end of each payment period. | [APPS] 1:Finance CALC E:Pmt_End |
| poissoncdf(μ,x) | Computes a cumulative probability at x for the discrete Poisson distribution with specified mean μ . | [2nd] [DISTR] DISTR C:poissoncdf(|
| poissonpdf(μ,x) | Computes a probability at x for the discrete Poisson distribution with the specified mean μ . | [2nd] [DISTR] DISTR B:poissonpdf(|
| Polar | Sets polar graphing mode. | † [MODE] Pol |
| <i>complex value</i> ►Polar | Displays <i>complex value</i> in polar format. | [MATH] CPX 7:Polar |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|-------------------------------------|
| PolarGC | Sets polar graphing coordinates format. | † [2nd] [FORMAT] PolarGC |
| prgmname | Executes the program <i>name</i> . | † [PRGM] CTRL D:prgm |
| ΣPrn(<i>pmt1,pmt2</i> [,<i>roundvalue</i>]) | Computes the sum, rounded to <i>roundvalue</i> , of the principal amount between <i>pmt1</i> and <i>pmt2</i> for an amortization schedule. | [APPS] 1:Finance CALC 0:ΣPrn(|
| prod(<i>list</i>[,<i>start,end</i>]) | Returns product of <i>list</i> elements between <i>start</i> and <i>end</i> . | [2nd] [LIST] MATH 6:prod(|
| Prompt <i>variableA</i> [<i>variableB,...,variable n</i>] | Prompts for value for <i>variableA</i> , then <i>variableB</i> , and so on. | † [PRGM] I/O 2:Prompt |
| 1-PropZInt(<i>x,n</i> [,<i>confidence level</i>]) | Computes a one-proportion <i>z</i> confidence interval. | † [STAT] TESTS A:1-PropZInt(|
| 2-PropZInt(<i>x1,n1,x2,n2</i> [,<i>confidence level</i>]) | Computes a two-proportion <i>z</i> confidence interval. | † [STAT] TESTS B:2-PropZInt(|
| 1-PropZTest(<i>p0,x,n</i> [,<i>alternative,drawflag</i>]) | Computes a one-proportion <i>z</i> test. <i>alternative</i> = -1 is <; <i>alternative</i> = 0 is ≠; <i>alternative</i> = 1 is >. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 5:1-PropZTest(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| 2-PropZTest(x_1, n_1, x_2, n_2, [<i>alternative</i>,<i>drawflag</i>]) | Computes a two-proportion z test. <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 6:2-PropZTest(|
| Pt-Change(x,y) | Reverses a point at (x,y) . | [2nd] [DRAW] POINTS 3:Pt-Change(|
| Pt-Off(x,y[,<i>mark</i>]) | Erases a point at (x,y) using <i>mark</i> . | [2nd] [DRAW] POINTS 2:Pt-Off(|
| Pt-On(x,y[,<i>mark</i>]) | Draws a point at (x,y) using <i>mark</i> . | [2nd] [DRAW] POINTS 1:Pt-On(|
| PwrReg [<i>Xlistname</i> , <i>Ylistname</i> , <i>freqlist</i> , <i>regequ</i>] | Fits a power regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC A:PwrReg |
| Pxl-Change($row, column$) | Reverses pixel at $(row, column)$; $0 \leq row \leq 62$ and $0 \leq column \leq 94$. | [2nd] [DRAW] POINTS 6:Pxl-Change(|
| Pxl-Off($row, column$) | Erases pixel at $(row, column)$; $0 \leq row \leq 62$ and $0 \leq column \leq 94$. | [2nd] [DRAW] POINTS 5:Pxl-Off(|
| Pxl-On($row, column$) | Draws pixel at $(row, column)$; $0 \leq row \leq 62$ and $0 \leq column \leq 94$. | [2nd] [DRAW] POINTS 4:Pxl-On(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|---|
| pxl-Test (<i>row, column</i>) | Returns 1 if pixel (<i>row, column</i>) is on, 0 if it is off; $0 \leq row \leq 62$ and $0 \leq column \leq 94$. | [2nd] [DRAW] POINTS 7: pxl-Test |
| P>Rx (<i>r, θ</i>) | Returns X , given polar coordinates <i>r</i> and θ or a list of polar coordinates. | [2nd] [ANGLE] ANGLE 7: P>Rx |
| P>Ry (<i>r, θ</i>) | Returns Y , given polar coordinates <i>r</i> and θ or a list of polar coordinates. | [2nd] [ANGLE] ANGLE 8: P>Ry |
| QuadReg [<i>Xlistname, Ylistname, freqlist, regequ</i>] | Fits a quadratic regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC 5: QuadReg |
| QuartReg [<i>Xlistname, Ylistname, freqlist, regequ</i>] | Fits a quartic regression model to <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> , and stores the regression equation to <i>regequ</i> . | [STAT] CALC 7: QuartReg |
| Radian | Sets radian angle mode. | † [MODE] Radian |
| rand [(<i>numtrials</i>)] | Returns a random number between 0 and 1 for a specified number of trials <i>numtrials</i> . | [MATH] PRB 1: rand |
| randBin (<i>numtrials, prob [,numsimulations]</i>) | Generates and displays a random real number from a specified Binomial distribution. | [MATH] PRB 7: randBin |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|--|
| randInt(<i>lower,upper</i> [,numtrials]) | Generates and displays a random integer within a range specified by <i>lower</i> and <i>upper</i> integer bounds for a specified number of trials <i>numtrials</i> . | MATH PRB 5:randInt(|
| randM(<i>rows,columns</i>) | Returns a random matrix of <i>rows</i> (1–99) × <i>columns</i> (1–99). | 2nd [MATRIX] MATH 6:randM(|
| randNorm(<i>μ,σ[,numtrials])</i> | Generates and displays a random real number from a specified Normal distribution specified by μ and σ for a specified number of trials <i>numtrials</i> . | MATH PRB 6:randNorm(|
| <i>re</i>^{<i>θi</i>} | Sets the mode to polar complex number mode (<i>re</i>^{<i>θi</i>}). | † [MODE] <i>re</i>^{<i>θi</i>} |
| Real | Sets mode to display complex results only when you enter complex numbers. | † [MODE] Real |
| real(<i>value</i>) | Returns the real part of a complex number or list of complex numbers. | MATH CPX 2:real(|
| RecallGDB <i>n</i> | Restores all settings stored in the graph database variable GDBn . | 2nd [DRAW] STO 4:RecallGDB |
| RecallPic <i>n</i> | Displays the graph and adds the picture stored in Picn . | 2nd [DRAW] STO 2:RecallPic |
| <i>complex value</i> ►Rect | Displays <i>complex value</i> or list in rectangular format. | MATH CPX 6:►Rect |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|--|
| RectGC | Sets rectangular graphing coordinates format. | † [2nd] [FORMAT] RectGC |
| ref(<i>matrix</i>) | Returns the row-echelon form of a <i>matrix</i> . | [2nd] [MATRIX] MATH A:ref(|
| :Repeat <i>condition</i> :commands :End :commands | Executes <i>commands</i> until <i>condition</i> is true. | † [PRGM] CTL 6:Repeat |
| Return | Returns to the calling program. | † [PRGM] CTL E:Return |
| round(<i>value</i>[,<i>#decimals</i>]) | Returns a number, expression, list, or matrix rounded to <i>#decimals</i> (≤ 9). | MATH NUM 2:round(|
| *row(<i>value,matrix,row</i>) | Returns a matrix with <i>row</i> of <i>matrix</i> multiplied by <i>value</i> and stored in <i>row</i> . | [2nd] [MATRIX] MATH E:*row(|
| row+(<i>matrix,rowA,rowB</i>) | Returns a matrix with <i>rowA</i> of <i>matrix</i> added to <i>rowB</i> and stored in <i>rowB</i> . | [2nd] [MATRIX] MATH D:row+(|
| *row+(<i>value,matrix, rowA,rowB</i>) | Returns a matrix with <i>rowA</i> of <i>matrix</i> multiplied by <i>value</i> , added to <i>rowB</i> , and stored in <i>rowB</i> . | [2nd] [MATRIX] MATH F:*row+(|
| rowSwap(<i>matrix,rowA, rowB</i>) | Returns a matrix with <i>rowA</i> of <i>matrix</i> swapped with <i>rowB</i> . | [2nd] [MATRIX] MATH C:rowSwap(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|--|
| rref(<i>matrix</i>) | Returns the reduced row-echelon form of a <i>matrix</i> . | [2nd] [MATRIX] MATH B:rref(|
| R>Pr(<i>x,y</i>) | Returns R , given rectangular coordinates <i>x</i> and <i>y</i> or a list of rectangular coordinates. | [2nd] [ANGLE] ANGLE 5:R>Pr(|
| R>Pθ(<i>x,y</i>) | Returns θ , given rectangular coordinates <i>x</i> and <i>y</i> or a list of rectangular coordinates. | [2nd] [ANGLE] ANGLE 6:R>Pθ(|
| 2-SampFTest [<i>listname1</i> , <i>listname2,freqlist1</i> , <i>freqlist2,alternative</i> , <i>drawflag</i>] (Data list input) | Performs a two-sample F test. <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS D:2-SampFTest |
| 2-SampFTest <i>Sx1,n1</i> , <i>Sx2,n2[,alternative</i> , <i>drawflag]</i> (Summary stats input) | Performs a two-sample F test. <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS D:2-SampFTest |
| 2-SampTInt [<i>listname1</i> , <i>listname2</i> , <i>freqlist1,freqlist2</i> , <i>confidence level,pooled</i>] (Data list input) | Computes a two-sample <i>t</i> confidence interval. <i>pooled</i> = 1 pools variances; <i>pooled</i> = 0 does not pool variances. | † [STAT] TESTS 0:2-SampTInt |
| 2-SampTInt <i>X̄1,Sx1,n1</i> , <i>X̄2,Sx2,n2</i> [<i>,confidence level,pooled</i>] (Summary stats input) | Computes a two-sample <i>t</i> confidence interval. <i>pooled</i> = 1 pools variances; <i>pooled</i> = 0 does not pool variances. | † [STAT] TESTS 0:2-SampTInt |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| 2-SampTTest [<i>listname1</i> , <i>listname2,freqlist1</i> , <i>freqlist2,alternative</i> , <i>pooled,drawflag</i>] (Data list input) | Computes a two-sample <i>t</i> test. <i>alternative</i> = 1 is <; <i>alternative</i> = 0 is ≠; <i>alternative</i> = 1 is >. <i>pooled</i> = 1 pools variances; <i>pooled</i> = 0 does not pool variances. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 4:2-SampTTest |
| 2-SampTTest \bar{x}_1,Sx_1,n_1 , $\bar{x}_2,Sx_2,n_2[,alternative$, <i>pooled,drawflag</i>] (Summary stats input) | Computes a two-sample <i>t</i> test. <i>alternative</i> = 1 is <; <i>alternative</i> = 0 is ≠; <i>alternative</i> = 1 is >. <i>pooled</i> = 1 pools variances; <i>pooled</i> = 0 does not pool variances. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 4:2-SampTTest |
| 2-SampZInt (σ_1,σ_2 [<i>listname1,listname2</i> , <i>freqlist1,freqlist2</i> , <i>confidence level</i>]) (Data list input) | Computes a two-sample <i>z</i> confidence interval. | † [STAT] TESTS 9:2-SampZInt(|
| 2-SampZInt (σ_1,σ_2 , $\bar{x}_1,n_1,\bar{x}_2,n_2$ [<i>confidence level</i>]) (Summary stats input) | Computes a two-sample <i>z</i> confidence interval. | † [STAT] TESTS 9:2-SampZInt(|
| 2-SampZTest (σ_1,σ_2 [<i>listname1,listname2</i> , <i>freqlist1,freqlist2</i> , <i>alternative,drawflag</i>]) (Data list input) | Computes a two-sample <i>z</i> test. <i>alternative</i> = 1 is <; <i>alternative</i> = 0 is ≠; <i>alternative</i> = 1 is >. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 3:2-SampZTest(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|--|
| 2-SampZTest($\sigma_1, \sigma_2,$ $\bar{x}_1, n_1, \bar{x}_2, n_2$ [,<i>alternative, drawflag</i>]) (Summary stats input) | Computes a two-sample z test. <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | † [STAT] TESTS 3:2-SampZTest(|
| Sci | Sets scientific notation display mode. | † [MODE] Sci |
| Select(<i>Xlistname</i>, <i>Ylistname</i>) | Selects one or more specific data points from a scatter plot or xyLine plot (only), and then stores the selected data points to two new lists, <i>Xlistname</i> and <i>Ylistname</i> . | [2nd] [LIST] OPS 8:Select(|
| Send(<i>variable</i>) | Sends contents of <i>variable</i> to the CBL 2/CBL or CBR System. | † [PRGM] I/O B:Send(|
| seq(<i>expression, variable, begin, end[, increment]</i>) | Returns list created by evaluating <i>expression</i> with regard to <i>variable</i> , from <i>begin</i> to <i>end</i> by <i>increment</i> . | [2nd] [LIST] OPS 5:seq(|
| Seq | Sets sequence graphing mode. | † [MODE] Seq |
| Sequential | Sets mode to graph functions sequentially. | † [MODE] Sequential |
| SetUpEditor | Removes all list names from the stat list editor, and then restores list names L1 through L6 to columns 1 through 6 . | [STAT] EDIT 5:SetUpEditor |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|--|
| SetUpEditor <i>listname1</i> [<i>listname2</i> ,..., <i>listname20</i>] | Removes all list names from the stat list editor, then sets it up to display one or more <i>listnames</i> in the specified order, starting with column 1. | STAT EDIT 5:SetUpEditor |
| Shade (<i>lowerfunc</i> , <i>upperfunc</i> [, <i>Xleft,Xright</i> , <i>pattern,patres</i>]) | Draws <i>lowerfunc</i> and <i>upperfunc</i> in terms of X on the current graph and uses <i>pattern</i> and <i>patres</i> to shade the area bounded by <i>lowerfunc</i> , <i>upperfunc</i> , <i>Xleft</i> , and <i>Xright</i> . | 2nd [DRAW] DRAW 7:Shade(|
| Shadeχ² (<i>lowerbound</i> , <i>upperbound,df</i>) | Draws the density function for the χ^2 distribution specified by degrees of freedom <i>df</i> and shades the area between <i>lowerbound</i> and <i>upperbound</i> . | 2nd [DISTR] DRAW 3:Shadeχ²(|
| ShadeF (<i>lowerbound</i> , <i>upperbound</i> , <i>numerator df</i> , <i>denominator df</i>) | Draws the density function for the F distribution specified by numerator <i>df</i> and denominator <i>df</i> and shades the area between <i>lowerbound</i> and <i>upperbound</i> . | 2nd [DISTR] DRAW 4:ShadeF(|
| ShadeNorm (<i>lowerbound</i> , <i>upperbound</i> [, μ,σ]) | Draws the normal density function specified by μ and σ and shades the area between <i>lowerbound</i> and <i>upperbound</i> . | 2nd [DISTR] DRAW 1:ShadeNorm(|
| Shade_t (<i>lowerbound</i> , <i>upperbound,df</i>) | Draws the density function for the Student-t distribution specified by degrees of freedom <i>df</i> , and shades the area between <i>lowerbound</i> and <i>upperbound</i> . | 2nd [DISTR] DRAW 2:Shade_t(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|---|
| Simul | Sets mode to graph functions simultaneously. | † [MODE] Simul |
| sin(value) | Returns the sine of a real number, expression, or list. | [SIN] |
| sin⁻¹(value) | Returns the arcsine of a real number, expression, or list. | [2nd] [SIN ⁻¹] |
| sinh(value) | Returns the hyperbolic sine of a real number, expression, or list. | [2nd] [CATALOG] sinh(|
| sinh⁻¹(value) | Returns the hyperbolic arcsine of a real number, expression, or list. | [2nd] [CATALOG] sinh⁻¹(|
| SinReg [<i>iterations</i> , <i>Xlistname</i> , <i>Ylistname</i> , <i>period</i> , <i>regequ</i>] | Attempts <i>iterations</i> times to fit a sinusoidal regression model to <i>Xlistname</i> and <i>Ylistname</i> using a <i>period</i> guess, and stores the regression equation to <i>regequ</i> . | [STAT] CALC C:SinReg |
| solve(expression,variable, guess,{lower,upper}) | Solves <i>expression</i> for <i>variable</i> , given an initial <i>guess</i> and <i>lower</i> and <i>upper</i> bounds within which the solution is sought. | † [MATH] MATH 0:solve(|
| SortA(listname) | Sorts elements of <i>listname</i> in ascending order. | [2nd] [LIST] OPS1:SortA(|
| SortA(keylistname, dependlist1[,dependlist2, ...,dependlist n]) | Sorts elements of <i>keylistname</i> in ascending order, then sorts each <i>dependlist</i> as a dependent list. | [2nd] [LIST] OPS 1:SortA(|
| SortD(listname) | Sorts elements of <i>listname</i> in descending order. | [2nd] [LIST] OPS2:SortD(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| SortD(<i>keylistname</i>, <i>dependlist1[,dependlist2,</i> <i>...,dependlist n])</i> | Sorts elements of <i>keylistname</i> in descending order, then sorts each <i>dependlist</i> as a dependent list. | [2nd] [LIST] OPS 2:SortD(|
| stdDev(<i>list[,freqlist]</i>) | Returns the standard deviation of the elements in <i>list</i> with frequency <i>freqlist</i> . | [2nd] [LIST] MATH 7:stdDev(|
| Stop | Ends program execution; returns to home screen. | † [PRGM] CTL F:Stop |
| Store: <i>value</i>→<i>variable</i> | Stores <i>value</i> in <i>variable</i> . | [STO]→ |
| StoreGDB <i>n</i> | Stores current graph in database GDB<i>n</i> . | [2nd] [DRAW] STO 3:StoreGDB |
| StorePic <i>n</i> | Stores current picture in picture Pic<i>n</i> . | [2nd] [DRAW] STO 1:StorePic |
| String→Equ(<i>string,Y= var</i>) | Converts <i>string</i> into an equation and stores it in <i>Y= var</i> . | [2nd] [CATALOG] String→Equ(|
| sub(<i>string,begin,length</i>) | Returns a string that is a subset of another <i>string</i> , from <i>begin</i> to <i>length</i> . | [2nd] [CATALOG] sub(|
| sum(<i>list[,start,end]</i>) | Returns the sum of elements of <i>list</i> from <i>start</i> to <i>end</i> . | [2nd] [LIST] MATH 5:sum(|
| tan(<i>value</i>) | Returns the tangent of a real number, expression, or list. | [TAN] |
| tan⁻¹(<i>value</i>) | Returns the arctangent of a real number, expression, or list. | [2nd] [TAN⁻¹] |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|--|--|
| Tangent (<i>expression,value</i>) | Draws a line tangent to <i>expression</i> at $X=value$. | [2nd] [DRAW] DRAW 5:Tangent(|
| tanh (<i>value</i>) | Returns hyperbolic tangent of a real number, expression, or list. | [2nd] [CATALOG] tanh(|
| tanh⁻¹ (<i>value</i>) | Returns the hyperbolic arctangent of a real number, expression, or list. | [2nd] [CATALOG] tanh⁻¹(|
| tcdf (<i>lowerbound, upperbound,df</i>) | Computes the Student- <i>t</i> distribution probability between <i>lowerbound</i> and <i>upperbound</i> for the specified degrees of freedom <i>df</i> . | [2nd] [DISTR] DISTR 5:tcdf(|
| Text (<i>row,column,text1, text2,...,text n</i>) | Writes <i>text</i> on graph beginning at pixel (<i>row,column</i>), where $0 \leq row \leq 57$ and $0 \leq column \leq 94$. | [2nd] [DRAW] DRAW 0:Text(|
| Then <i>See If:Then</i> | | |
| Time | Sets sequence graphs to plot with respect to time. | † [2nd] [FORMAT] Time |
| TInterval [<i>listname, freqlist,confidence level</i>] (Data list input) | Computes a <i>t</i> confidence interval. | † [STAT] TESTS 8:TInterval |
| TInterval \bar{x}, S_x, n [, <i>confidence level</i>] (Summary stats input) | Computes a <i>t</i> confidence interval. | † [STAT] TESTS 8:TInterval |
| tpdf (<i>x,df</i>) | Computes the probability density function (pdf) for the Student- <i>t</i> distribution at a specified <i>x</i> value with specified degrees of freedom <i>df</i> . | [2nd] [DISTR] DISTR 4:tpdf(|

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|---|
| Trace | Displays the graph and enters TRACE mode. | TRACE |
| T-Test $\mu 0[,listname,$ $freqlist,alternative,$ $drawflag]$ (Data list input) | Performs a <i>t</i> test with frequency <i>freqlist</i> . <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | \dagger STAT TESTS 2:T-Test |
| T-Test $\mu 0, \bar{x}, S_x, n$ [, <i>alternative</i> , <i>drawflag</i>] (Summary stats input) | Performs a <i>t</i> test with frequency <i>freqlist</i> . <i>alternative</i> = 1 is $<$; <i>alternative</i> = 0 is \neq ; <i>alternative</i> = 1 is $>$. <i>drawflag</i> = 1 draws results; <i>drawflag</i> = 0 calculates results. | \dagger STAT TESTS 2:T-Test |
| tvm_FV[(<i>N,I%,PV,PMT,</i> <i>P/Y,C/Y</i>)] | Computes the future value. | APPS 1:Finance CALC 6:tvm_FV |
| tvm_I%[(<i>N,PV,PMT,FV,</i> <i>P/Y,C/Y</i>)] | Computes the annual interest rate. | APPS 1:Finance CALC 3:tvm_(|
| tvm_N[(<i>I%,PV,PMT,FV,</i> <i>P/Y,C/Y</i>)] | Computes the number of payment periods. | APPS 1:Finance CALC 5:tvm_(|
| tvm_Pmt[(<i>N,I%,PV,FV,</i> <i>P/Y,C/Y</i>)] | Computes the amount of each payment. | APPS 1:Finance CALC 2:tvm_Pmt |
| tvm_PV[(<i>N,I%,PMT,FV,</i> <i>P/Y,C/Y</i>)] | Computes the present value. | APPS 1:Finance CALC 4:tvm_PV |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|--|
| UnArchive | Moves the specified variables from the user data archive memory to RAM. To archive variables, use Archive . | [2nd] [MEM] 6:UnArchive |
| uvAxes | Sets sequence graphs to plot u(n) on the x-axis and v(n) on the y-axis. | \dagger [2nd] [FORMAT] uv |
| uwAxes | Sets sequence graphs to plot u(n) on the x-axis and w(n) on the y-axis. | \dagger [2nd] [FORMAT] uw |
| 1-Var Stats [<i>Xlistname, freqlist</i>] | Performs one-variable analysis on the data in <i>Xlistname</i> with frequency <i>freqlist</i> . | STAT CALC 1:1-Var Stats |
| 2-Var Stats [<i>Xlistname, Ylistname freqlist</i>] | Performs two-variable analysis on the data in <i>Xlistname</i> and <i>Ylistname</i> with frequency <i>freqlist</i> . | STAT CALC 2:2-Var Stats |
| variance (<i>list[,freqlist]</i>) | Returns the variance of the elements in <i>list</i> with frequency <i>freqlist</i> . | [2nd] [LIST] MATH 8:variance(|
| Vertical <i>x</i> | Draws a vertical line at <i>x</i> . | [2nd] [DRAW] DRAW 4:Vertical |
| vwAxes | Sets sequence graphs to plot v(n) on the x-axis and w(n) on the y-axis. | \dagger [2nd] [FORMAT] vw |
| Web | Sets sequence graphs to trace as webs. | \dagger [2nd] [FORMAT] Web |
| :While <i>condition</i> :commands :End :command | Executes <i>commands</i> while <i>condition</i> is true. | \dagger [PRGM] CTL 5:While |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|---|
| valueA xor valueB | Returns 1 if only <i>valueA</i> or <i>valueB</i> = 0. <i>valueA</i> and <i>valueB</i> can be real numbers, expressions, or lists. | [2nd] [TEST] LOGIC 3:xor |
| ZBox | Displays a graph, lets you draw a box that defines a new viewing window, and updates the window. | † [ZOOM] ZOOM 1:ZBox |
| ZDecimal | Adjusts the viewing window so that $\Delta X=0.1$ and $\Delta Y=0.1$, and displays the graph screen with the origin centered on the screen. | † [ZOOM] ZOOM 4:ZDecimal |
| ZInteger | Redefines the viewing window using these dimensions: $\Delta X=1$ Xscl=10 $\Delta Y=1$ Yscl=10 | † [ZOOM] ZOOM 8:ZInteger |
| ZInterval σ [,listname, <i>freqlist</i> ,confidence level] (Data list input) | Computes a <i>z</i> confidence interval. | † [STAT] TESTS 7:ZInterval |
| ZInterval σ,\bar{x},n [,confidence level] (Summary stats input) | Computes a <i>z</i> confidence interval. | † [STAT] TESTS 7:ZInterval |
| Zoom In | Magnifies the part of the graph that surrounds the cursor location. | † [ZOOM] ZOOM 2:Zoom In |
| Zoom Out | Displays a greater portion of the graph, centered on the cursor location. | † [ZOOM] ZOOM 3:Zoom Out |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---------------------------------------|---|--|
| ZoomFit | Recalculates Ymin and Ymax to include the minimum and maximum Y values, between Xmin and Xmax , of the selected functions and replots the functions. | † ZOOM ZOOM 0:ZoomFit |
| ZoomRcl | Graphs the selected functions in a user-defined viewing window. | † ZOOM MEMORY 3:ZoomRcl |
| ZoomStat | Redefines the viewing window so that all statistical data points are displayed. | † ZOOM ZOOM 9:ZoomStat |
| ZoomSto | Immediately stores the current viewing window. | † ZOOM MEMORY 2:ZoomSto |
| ZPrevious | Replots the graph using the window variables of the graph that was displayed before you executed the last ZOOM instruction. | † ZOOM MEMORY 1:ZPrevious |
| ZSquare | Adjusts the X or Y window settings so that each pixel represents an equal width and height in the coordinate system, and updates the viewing window. | † ZOOM ZOOM 5:ZSquare |
| ZStandard | Replots the functions immediately, updating the window variables to the default values. | † ZOOM ZOOM 6:ZStandard |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---|---|---|
| Z-Test ($\mu_0, \sigma, [listname,$ $freqlist, alternative,$ $drawflag]$) (Data list input) | Performs a z test with frequency $freqlist$. $alternative = -1$ is $<$; $alternative = 0$ is \neq ; $alternative = 1$ is $>$. $drawflag = 1$ draws results; $drawflag = 0$ calculates results. | † [STAT] TESTS 1:Z-Test(|
| Z-Test ($\mu_0, \sigma, \bar{x}, n$ [, $alternative, drawflag]$) (Summary stats input) | Performs a z test. $alternative = -1$ is $<$; $alternative = 0$ is \neq ; $alternative = 1$ is $>$. $drawflag = 1$ draws results; $drawflag = 0$ calculates results. | † [STAT] TESTS 1:Z-Test(|
| ZTrig | Replots the functions immediately, updating the window variables to preset values for plotting trig functions. | † [ZOOM] ZOOM 7:ZTrig |
| Factorial: $value!$ | Returns factorial of $value$. | [MATH] PRB 4!:! |
| Factorial: $list!$ | Returns factorial of $list$ elements. | [MATH] PRB 4!:! |
| Degrees notation: $value^\circ$ | Interprets $value$ as degrees; designates degrees in DMS format. | [2nd] [ANGLE] ANGLE 1:(|
| Radian: $angle^r$ | Interprets $angle$ as radians. | [2nd] [ANGLE] ANGLE 3:r |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---------------------------------------|---|-------------------------------------|
| Transpose: $matrix^T$ | Returns a matrix in which each element (row, column) is swapped with the corresponding element (column, row) of $matrix$. | [2nd] [MATRIX] MATH 2:T |
| $x^{th}\sqrt{value}$ | Returns $x^{th}\sqrt{value}$. | [MATH] MATH 5:X(|
| $x^{th}\sqrt{list}$ | Returns $x^{th}\sqrt{list}$ elements. | [MATH] MATH 5:X(|
| $list^X\sqrt{value}$ | Returns $list$ roots of $value$. | [MATH] MATH 5:X(|
| $listA^X\sqrt{listB}$ | Returns $listA$ roots of $listB$. | [MATH] MATH 5:X(|
| Cube: $value^3$ | Returns the cube of a real or complex number, expression, list, or square matrix. | [MATH] MATH 3:3 |
| Cube root: $3\sqrt{(value)}$ | Returns the cube root of a real or complex number, expression, or list. | [MATH] MATH 4:3(|
| Equal: $valueA=valueB$ | Returns 1 if $valueA = valueB$. Returns 0 if $valueA \neq valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, lists, or matrices. | [2nd] [TEST] TEST 1:= |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|--|
| Not equal: $valueA \neq valueB$ | Returns 1 if $valueA \neq valueB$. Returns 0 if $valueA = valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, lists, or matrices. | [2nd] [TEST] TEST 2:= |
| Less than: $valueA < valueB$ | Returns 1 if $valueA < valueB$. Returns 0 if $valueA \geq valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, or lists. | [2nd] [TEST] TEST 5:< |
| Greater than: $valueA > valueB$ | Returns 1 if $valueA > valueB$. Returns 0 if $valueA \leq valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, or lists. | [2nd] [TEST] TEST 3:> |
| Less than or equal: $valueA \leq valueB$ | Returns 1 if $valueA \leq valueB$. Returns 0 if $valueA > valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, or lists. | [2nd] [TEST] TEST 6:\leq |
| Greater than or equal: $valueA \geq valueB$ | Returns 1 if $valueA \geq valueB$. Returns 0 if $valueA < valueB$. $valueA$ and $valueB$ can be real or complex numbers, expressions, or lists. | [2nd] [TEST] TEST 4:\geq |
| Inverse: $value^{-1}$ | Returns 1 divided by a real or complex number or expression. | [x ⁻¹] |
| Inverse: $list^{-1}$ | Returns 1 divided by $list$ elements. | [x ⁻¹] |
| Inverse: $matrix^{-1}$ | Returns $matrix$ inverted. | [x ⁻¹] |
| Square: $value^2$ | Returns $value$ multiplied by itself. $value$ can be a real or complex number or expression. | [x ²] |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|---------------------------------------|--|-------------------------------------|
| Square: $list^2$ | Returns $list$ elements squared. | [x^2] |
| Square: $matrix^2$ | Returns $matrix$ multiplied by itself. | [x^2] |
| Powers: $value^{power}$ | Returns $value$ raised to $power$. $value$ can be a real or complex number or expression. | [\wedge] |
| Powers: $list^{power}$ | Returns $list$ elements raised to $power$. | [\wedge] |
| Powers: $value^{list}$ | Returns $value$ raised to $list$ elements. | [\wedge] |
| Powers: $matrix^{power}$ | Returns $matrix$ elements raised to $power$. | [\wedge] |
| Negation: $-value$ | Returns the negative of a real or complex number, expression, list, or matrix. | [(-)] |
| Power of ten: $10^{(value)}$ | Returns 10 raised to the $value$ power. $value$ can be a real or complex number or expression. | [2nd] [10^x] |
| Power of ten: $10^{(list)}$ | Returns a list of 10 raised to the $list$ power. | [2nd] [10^x] |
| Square root: $\sqrt{(value)}$ | Returns square root of a real or complex number, expression, or list. | [2nd] [$\sqrt{ }$] |
| Multiplication: $valueA * valueB$ | Returns $valueA$ times $valueB$. | [\times] |
| Multiplication: $value * list$ | Returns $value$ times each $list$ element. | [\times] |
| Multiplication: $list * value$ | Returns each $list$ element times $value$. | [\times] |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|---|-------------------------------------|
| Multiplication: <i>listA</i> * <i>listB</i> | Returns <i>listA</i> elements times <i>listB</i> elements. | <input checked="" type="checkbox"/> |
| Multiplication: <i>value</i> * <i>matrix</i> | Returns <i>value</i> times <i>matrix</i> elements. | <input checked="" type="checkbox"/> |
| Multiplication: <i>matrixA</i> * <i>matrixB</i> | Returns <i>matrixA</i> times <i>matrixB</i> . | <input checked="" type="checkbox"/> |
| Division: <i>valueA</i> / <i>valueB</i> | Returns <i>valueA</i> divided by <i>valueB</i> . | <input checked="" type="checkbox"/> |
| Division: <i>list</i> / <i>value</i> | Returns <i>list</i> elements divided by <i>value</i> . | <input checked="" type="checkbox"/> |
| Division: <i>value</i> / <i>list</i> | Returns <i>value</i> divided by <i>list</i> elements. | <input checked="" type="checkbox"/> |
| Division: <i>listA</i> / <i>listB</i> | Returns <i>listA</i> elements divided by <i>listB</i> elements. | <input checked="" type="checkbox"/> |
| Addition: <i>valueA</i> + <i>valueB</i> | Returns <i>valueA</i> plus <i>valueB</i> . | <input checked="" type="checkbox"/> |
| Addition: <i>list</i> + <i>value</i> | Returns <i>list</i> in which <i>value</i> is added to each <i>list</i> element. | <input checked="" type="checkbox"/> |
| Addition: <i>listA</i> + <i>listB</i> | Returns <i>listA</i> elements plus <i>listB</i> elements. | <input checked="" type="checkbox"/> |
| Addition: <i>matrixA</i> + <i>matrixB</i> | Returns <i>matrixA</i> elements plus <i>matrixB</i> elements. | <input checked="" type="checkbox"/> |
| Concatenation: <i>string1</i> + <i>string2</i> | Concatenates two or more strings. | <input checked="" type="checkbox"/> |
| Subtraction: <i>valueA</i> - <i>valueB</i> | Subtracts <i>valueB</i> from <i>valueA</i> . | <input checked="" type="checkbox"/> |
| Subtraction: <i>value</i> - <i>list</i> | Subtracts <i>list</i> elements from <i>value</i> . | <input checked="" type="checkbox"/> |

| Function or Instruction/ Arguments | Result | Key or Keys/ Menu or Screen/Item |
|--|--|---|
| Subtraction: <i>list-value</i> | Subtracts <i>value</i> from <i>list</i> elements. | $\boxed{-}$ |
| Subtraction: <i>listA-listB</i> | Subtracts <i>listB</i> elements from <i>listA</i> elements. | $\boxed{-}$ |
| Subtraction: <i>matrixA-matrixB</i> | Subtracts <i>matrixB</i> elements from <i>matrixA</i> elements. | $\boxed{-}$ |
| Minutes notation: <i>degrees°minutes'seconds"</i> | Interprets <i>minutes</i> angle measurement as minutes. | $\boxed{2^{\text{nd}}} \boxed{\text{ANGLE}}$ $\boxed{\text{ANGLE 2:}}$ |
| Seconds notation: <i>degrees°minutes'seconds"</i> | Interprets <i>seconds</i> angle measurement as seconds. | $\boxed{\text{ALPHA}} \boxed{["]}$ |

TI-83 Plus Menu Map

The TI-83 Plus Menu Map begins at the top-left corner of the keyboard and follows the keyboard layout from left to right. Default values and settings are shown.

| [Y=] | | | |
|-------------|-------------|-------------|-------------|
| (Func mode) | (Par mode) | (Pol mode) | (Seq mode) |
| Plot1 Plot2 | Plot1 Plot2 | Plot1 Plot2 | Plot1 Plot2 |
| Plot3 | Plot3 | Plot3 | Plot3 |
| \Y1= | \X1T= | \r1= | nMin=1 |
| \Y2= | \Y1T= | \r2= | '.u(n)= |
| \Y3= | \X2T= | \r3= | u(nMin)= |
| \Y4= | \Y2T= | \r4= | '.v(n)= |
| ... | ... | \r5= | v(nMin)= |
| \Y9= | \X6T= | \r6= | '.w(n)= |
| \Y0= | \Y6T= | | w(nMin)= |

| [2nd] [STAT PLOT] | [2nd] [STAT PLOT] | [2nd] [STAT PLOT] | [2nd] [STAT PLOT] |
|---------------------|-------------------|-------------------|-------------------|
| STAT PLOTS | (PRGM editor) | (PRGM editor) | (PRGM editor) |
| 1:Plot1...Off | PLOTS | TYPE | MARK |
| \u2296 L1 L2 \u2296 | 1:Plot1(| 1:Scatter | 1:\u2296 |
| 2:Plot2...Off | 2:Plot2(| 2:xyLine | 2:+ |
| \u2296 L1 L2 \u2296 | 3:Plot3(| 3:Histogram | 3:• |
| 3:Plot3...Off | 4:PlotsOff | 4:ModBoxplot | |
| \u2296 L1 L2 \u2296 | 5:PlotsOn | 5:Boxplot | |
| 4:PlotsOff | | 6:NormProbPlot | |
| 5:PlotsOn | | | |

WINDOW

| | | | |
|-------------|-----------------|-----------------|-------------|
| (Func mode) | (Par mode) | (Pol mode) | (Seq mode) |
| WINDOW | WINDOW | WINDOW | WINDOW |
| Xmin=-10 | Tmin=0 | θmin=0 | nMin=1 |
| Xmax=10 | Tmax= $\pi*2$ | θmax= $\pi*2$ | nMax=10 |
| Xscl=1 | Tstep= $\pi/24$ | θstep= $\pi/24$ | PlotStart=1 |
| Ymin=-10 | Xmin=-10 | Xmin=-10 | PlotStep=1 |
| Ymax=10 | Xmax=10 | Xmax=10 | Xmin=-10 |
| Yscl=1 | Xscl=1 | Xscl=1 | Xmax=10 |
| Xres=1 | Ymin=-10 | Ymin=-10 | Xscl=1 |
| | Ymax=10 | Ymax=10 | Ymin=-10 |
| | Yscl=1 | Yscl=1 | Ymax=10 |
| | | | Yscl=1 |

[2nd] [TBLSET]**[2nd]** [TBLSET]

| | |
|-----------------|-----------------|
| TABLE SETUP | (PRGM editor) |
| TblStart=0 | TABLE SETUP |
| ΔTbl=1 | Indpnt:Auto Ask |
| Indpnt:Auto Ask | Depend:Auto Ask |
| Depend:Auto Ask | |

ZOOM

| | | |
|-------------|-----------------|------------------|
| ZOOM | MEMORY | MEMORY |
| 1:ZBox | 1:ZPrevious | (Set Factors...) |
| 2:Zoom In | 2:ZoomSto | ZOOM FACTORS |
| 3:Zoom Out | 3:ZoomRcl | XFact=4 |
| 4:ZDecimal | 4:SetFactors... | YFact=4 |
| 5:ZSquare | | |
| 6:ZStandard | | |
| 7:ZTrig | | |
| 8:ZInteger | | |
| 9:ZoomStat | | |
| 0:ZoomFit | | |

[2nd] [FORMAT]

| | | | | | | |
|---------------------------------|----------|----------|----------|----|----|----|
| (Func/Par/Pol modes) (Seq mode) | | | | | | |
| RectGC | PolarGC | Time | Web | uv | vw | uw |
| CoordOn | CoordOff | RectGC | PolarGC | | | |
| GridOff | GridOn | CoordOn | CoordOff | | | |
| AxesOn | AxesOff | GridOff | GridOn | | | |
| LabelOff | LabelOn | AxesOn | AxesOff | | | |
| ExprOn | ExprOff | LabelOff | LabelOn | | | |
| | | ExprOn | ExprOff | | | |

[2nd] [CALC]

| (Func mode) | (Par mode) | (Pol mode) | (Seq mode) |
|------------------|------------|------------|------------|
| CALCULATE | CALCULATE | CALCULATE | CALCULATE |
| 1:value | 1:value | 1:value | 1:value |
| 2:zero | 2:dy/dx | 2:dy/dx | |
| 3:minimum | 3:dy/dt | 3:dr/dθ | |
| 4:maximum | 4:dx/dt | | |
| 5:intersect | | | |
| 6:dy/dx | | | |
| 7: $\int f(x)dx$ | | | |

[MODE]

Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real $a+bi$ $re^{\theta i}$
Full Horiz G-T

[2nd] [LINK]

| | |
|--------------------|-----------|
| SEND | RECEIVE |
| 1:A11+... | 1:Receive |
| 2:A11-... | |
| 3:Prgm... | |
| 4:List... | |
| 5:Lists to TI82... | |
| 6:GDB... | |
| 7:Pic... | |
| 8:Matrix... | |
| 9:Real... | |
| 0:Complex... | |
| A:Y-Vars... | |
| B:String... | |
| C:Apps... | |
| D:AppVars... | |
| E:Group... | |
| F:SendId | |
| G:SendOS | |
| H:Back Up... | |

STAT

| EDIT | CALC | TESTS |
|---------------|----------------|----------------------|
| 1>Edit... | 1:1-Var Stats | 1:Z-Test... |
| 2:SortA(| 2:2-Var Stats | 2:T-Test... |
| 3:SortD(| 3:Med-Med | 3:2-SampZTest... |
| 4:ClrList | 4:LinReg(ax+b) | 4:2-SampTTest... |
| 5:SetUpEditor | 5:QuadReg | 5:1-PropZTest... |
| | 6:CubicReg | 6:2-PropZTest... |
| | 7:QuartReg | 7:ZInterval... |
| | 8:LinReg(a+bx) | 8:TInterval... |
| | 9:LnReg | 9:2-SampZInt... |
| | 0:ExpReg | 0:2-SampTInt... |
| | A:PwrReg | A:1-PropZInt... |
| | B:Logistic | B:2-PropZInt... |
| | C:SinReg | C: χ^2 -Test... |
| | | D:2-SampFTest... |
| | | E:LinRegTTest... |
| | | F:ANOVA(|

[2nd] [LIST]

| NAMES | OPS | MATH |
|------------|------------------------------------|-------------|
| 1:listname | 1:SortA(| 1:min(|
| 2:listname | 2:SortD(| 2:max(|
| 3:listname | 3:dim(| 3:mean(|
| ... | 4:Fill(| 4:median(|
| | 5:seq(| 5:sum(|
| | 6:cumSum(| 6:prod(|
| | 7: Δ List(| 7:stdDev(|
| | 8:Select(| 8:variance(|
| | 9:augment(| |
| | 0:List \blacktriangleright matr(| |
| | A:Matr \blacktriangleright list(| |
| | B:L | |

[MATH]

| MATH | NUM | CPX | PRB |
|-------------------------------|----------|--------------------------------|-------------|
| 1: \blacktriangleright Frac | 1:abs(| 1:conj(| 1:rand |
| 2: \blacktriangleright Dec | 2:round(| 2:real(| 2:nPr |
| 3: 3 | 3:iPart(| 3:imag(| 3:nCr |
| 4: $^3\sqrt{}$ (| 4:fPart(| 4:angle(| 4:! |
| 5: $X\sqrt{}$ | 5:int(| 5:abs(| 5:randInt(|
| 6:fMin(| 6:min(| 6: \blacktriangleright Rect | 6:randNorm(|
| 7:fMax(| 7:max(| 7: \blacktriangleright Polar | 7:randBin(|
| 8:nDeriv(| 8:lcm(| | |
| 9:fnInt(| 9:gcd(| | |
| 0:Solver... | | | |

[2nd] [TEST]

| TEST | LOGIC |
|------|--------|
| 1:= | 1:and |
| 2:≠ | 2:or |
| 3:> | 3:xor |
| 4:≥ | 4:not(|
| 5:< | |
| 6:≤ | |

[2nd] [MATRIX]

| NAMES | MATH | EDIT |
|-------|--------------|-------|
| 1:[A] | 1:det(| 1:[A] |
| 2:[B] | 2:T | 2:[B] |
| 3:[C] | 3:dim(| 3:[C] |
| 4:[D] | 4:Fill(| 4:[D] |
| 5:[E] | 5:identity(| 5:[E] |
| 6:[F] | 6:randM(| 6:[F] |
| 7:[G] | 7:augment(| 7:[G] |
| 8:[H] | 8:Matr►list(| 8:[H] |
| 9:[I] | 9>List►matr(| 9:[I] |
| 0:[J] | 0:cumSum(| 0:[J] |
| | A:ref(| |
| | B:rref(| |
| | C:rowSwap(| |
| | D:row+(| |
| | E:/*row(| |
| | F:/*row+(| |

[2nd] [ANGLE]

| ANGLE |
|---------|
| 1:° |
| 2:' |
| 3:r |
| 4:DMS |
| 5:R►Pr(|
| 6:R►Pθ(|
| 7:P►Rx(|
| 8:P►Ry(|

PRGM

| | | |
|----------------|----------------|--------------|
| EXEC | EDIT | NEW |
| 1: <i>name</i> | 1: <i>name</i> | 1:Create New |
| 2: <i>name</i> | 2: <i>name</i> | |
| ... | ... | |

PRGM

| | | |
|---------------|---------------|----------------|
| (PRGM editor) | (PRGM editor) | (PRGM editor) |
| CTL | I/O | EXEC |
| 1:If | 1:Input | 1: <i>name</i> |
| 2:Then | 2:Prompt | 2: <i>name</i> |
| 3:Else | 3:Disp | ... |
| 4:For(| 4:DispGraph | |
| 5:While | 5:DispTable | |
| 6:Repeat | 6:Output(| |
| 7:End | 7:getKey | |
| 8:Pause | 8:ClrHome | |
| 9:Lbl | 9:ClrTable | |
| 0:Goto | 0:GetCalc(| |
| A:IS>(| A:Get(| |
| B:DS<(| B:Send(| |
| C:Menu(| | |
| D:prgm | | |
| E:Return | | |
| F:Stop | | |
| G:DelVar | | |
| H:GraphStyle(| | |

[2nd] [DRAW]

| DRAW | POINTS | STO |
|--------------|---------------|-------------|
| 1:ClrDraw | 1:Pt-On(| 1:StorePic |
| 2:Line(| 2:Pt-Off(| 2:RecallPic |
| 3:Horizontal | 3:Pt-Change(| 3:StoreGDB |
| 4:Vertical | 4:Px1-On(| 4:RecallGDB |
| 5:Tangent(| 5:Px1-Off(| |
| 6:DrawF | 6:Px1-Change(| |
| 7:Shade(| 7:px1-Test(| |
| 8:DrawInv | | |
| 9:Circle(| | |
| 0:Text(| | |
| A:Pen | | |

[VARS]

| VARS | Y-VARS |
|-----------------|-----------------|
| 1:Window... | 1:Function... |
| 2:Zoom... | 2:Parametric... |
| 3:GDB... | 3:Polar... |
| 4:Picture... | 4:On/Off... |
| 5:Statistics... | |
| 6:Table... | |
| 7:String... | |

VARS

| (Window...) | (Window...) | (Window...) |
|-------------|-------------|--------------------|
| X/Y | T/θ | U/V/W |
| 1:Xmin | 1:Tmin | 1:u(<i>nMin</i>) |
| 2:Xmax | 2:Tmax | 2:v(<i>nMin</i>) |
| 3:Xscl | 3:Tstep | 3:w(<i>nMin</i>) |
| 4:Ymin | 4:θmin | 4: <i>nMin</i> |
| 5:Ymax | 5:θmax | 5: <i>nMax</i> |
| 6:Yscl | 6:θstep | 6:PlotStart |
| 7:Xres | | 7:PlotStep |
| 8:ΔX | | |
| 9:ΔY | | |
| 0:XFact | | |
| A:YFact | | |

VARS

| (Zoom...) | (Zoom...) | (Zoom...) |
|-----------|-----------|---------------------|
| ZX/ZY | ZT/Zθ | ZU |
| 1:ZXmin | 1:ZTmin | 1:Zu(<i>nMin</i>) |
| 2:ZXmax | 2:ZTmax | 2:Zv(<i>nMin</i>) |
| 3:ZXscl | 3:ZTstep | 3:Zw(<i>nMin</i>) |
| 4:ZYmin | 4:Zθmin | 4:ZnMin |
| 5:ZYmax | 5:Zθmax | 5:ZnMax |
| 6:ZYscl | 6:Zθstep | 6:ZPlotStart |
| 7:ZXres | | 7:ZPlotStep |

VARS

```
(GDB...)      (Picture...
GRAPH DATABASE )
1:GDB1        PICTURE
2:GDB2        1:Pic1
...           2:Pic2
9:GDB9        ...
0:GDB0        9:Pic9
               0:Pic0
```

VARS

| (Statistics...) | (Statistics...) | (Statistics...) | (Statistics...) | (Statistics...) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| XY | Σ | EQ | TEST | PTS |
| 1:n | 1: Σx | 1:RegEQ | 1:p | 1:x1 |
| 2: \bar{x} | 2: Σx^2 | 2:a | 2:z | 2:y1 |
| 3:Sx | 3: Σy | 3:b | 3:t | 3:x2 |
| 4: σx | 4: Σy^2 | 4:c | 4: χ^2 | 4:y2 |
| 5: \bar{y} | 5: Σxy | 5:d | 5:F | 5:x3 |
| 6:Sy | | 6:e | 6:df | 6:y3 |
| 7: σy | | 7:r | 7: \hat{p} | 7:Q1 |
| 8:minX | | 8: r^2 | 8: \hat{p}_1 | 8:Med |
| 9:maxX | | 9: R^2 | 9: \hat{p}_2 | 9:Q3 |
| 0:minY | | | 0:s | |
| A:maxY | | | A: \bar{x}_1 | |
| | | | B: \bar{x}_2 | |
| | | | C:Sx1 | |
| | | | D:Sx2 | |
| | | | E:Sxp | |
| | | | F:n1 | |
| | | | G:n2 | |
| | | | H:lower | |
| | | | I:upper | |

VARS

| (Table...) | (String...) |
|-----------------|-------------|
| TABLE | STRING |
| 1:TblStart | 1:Str1 |
| 2: Δ Tbl | 2:Str2 |
| 3:TblInput | 3:Str3 |
| | 4:Str4 |
| | ... |
| | 9:Str9 |
| | 0:Str0 |

Y-VARS

| (Function...) | (Parametric...) | (Polar...) | (On/Off...) |
|---------------|-----------------|------------|-------------|
| FUNCTION | PARAMETRIC | POLAR | ON/OFF |
| 1:Y1 | 1:X1T | 1:r1 | 1:FnOn |
| 2:Y2 | 2:Y1T | 2:r2 | 2:FnOff |
| 3:Y3 | 3:X2T | 3:r3 | |
| 4:Y4 | 4:Y2T | 4:r4 | |
| ... | ... | 5:r5 | |
| 9:Y9 | A:X6T | 6:r6 | |
| 0:Y0 | B:Y6T | | |

[2nd] [DISTR]

| | |
|------------------|--------------------|
| DISTR | DRAW |
| 1:normalpdf(| 1:ShadeNorm(|
| 2:normalcdf(| 2:Shade_t(|
| 3:invNorm(| 3:Shade χ^2 (|
| 4:tpdf(| 4:ShadeF(|
| 5:tcdf(| |
| 6: χ^2 pdf(| |
| 7: χ^2 cdf(| |
| 8:Fpdf(| |
| 9:Fcdf(| |
| 0:binompdf(| |
| A:binomcdf(| |
| B:poissonpdf(| |
| C:poissoncdf(| |
| D:geometpdf(| |
| E:geometcdf(| |

APPS

1:Finance

2:CBL/CBR

Finance

CALC
1:TVM
Solver...
2:tvm_Pmt
3:tvm_I%
4:tvm_PV
5:tvm_N
6:tvm_FV
7:npv()
8:irr()
9:bal()
0: Σ Prn()
A: Σ Int()
B: \blacktriangleright Nom()
C: \blacktriangleright Eff()
D:dbd()
E:Pmt_End
F:Pmt_Bgn

CBL/CBR

1:N
2:I%
3:PV
4:PMT
5:FV
6:P/Y
7:C/Y
8:QUIT

1:GAUGE

2:DATA LOGGER

3:CBR

[2nd] [MEM]

MEMORY

MEMORY (Mem Mgmt/Del...)
1:About RAM FREE 25631
2:Mem Mgmt/Del... ARC FREE 131069
3:Clear Entries 1:All...
4:ClrAllLists 2:Real...
5:Archive 3:Complex...
6:UnArchive 4>List...
7:Reset... 5:Matrix...
8:Group 6:Y-Vars...
7:Prgm...
8:Pic...
9:GDB...
0:String...
A:Apps...
B:AppVars...
C:Group...

MEMORY (Reset...)

RAM

1:All RAM...

2:Defaults...

Resetting RAM
erases all data
and programs from
RAM.

ARCHIVE

1:Vars...

2:Apps...

B:Both...

Resetting Both
erases all data,
programs and Apps
from Archive.

ALL

1:All Memory...

Resetting ALL
erases all data,
programs and Apps
from RAM and
Archive.

RAM

RESET RAM

1>No

2:Reset

Resetting RAM
erases all data
and programs from
RAM.

RESET DEFAULTS

1>No

2:Reset

ARCHIVE

RESET ARC VARS

1:No

2:Reset

Resetting Vars
erases all data
and programs from
Archive.

RESET ARC APPS

1:No

2:Reset

Resetting Apps
erases all Apps
from Archive.

RESET ARC BOTH

1:No

2:Reset

Resetting Both
erases all data,
programs and Apps
from Archive.

ALL

RESET MEMORY

1:No

2:Reset

Resetting ALL
will delete all
data, programs &
Apps from RAM &
Archive.

MEMORY (GROUP...)

GROUP UNGROUP

1>Create New

MEMORY (UNGROUP...)

1 : *name*
2 : *name*
...

[**2nd**] [CATALOG]

CATALOG
cosh()
cosh⁻¹()
...
Equ►String()
expr()
...
inString()
...
length()
...
sinh()
sinh⁻¹()
...
String►Equ()
sub()
...
tanh()
tanh⁻¹()

Variables

User Variables

The TI-83 Plus uses the variables listed below in various ways. Some variables are restricted to specific data types.

The variables **A** through **Z** and θ are defined as real or complex numbers. You may store to them. The TI-83 Plus can update **X**, **Y**, **R**, θ , and **T** during graphing, so you may want to avoid using these variables to store nongraphing data.

The variables (list names) **L₁** through **L₆** are restricted to lists; you cannot store another type of data to them.

The variables (matrix names) **[A]** through **[J]** are restricted to matrices; you cannot store another type of data to them.

The variables **Pic1** through **Pic9** and **Pic0** are restricted to pictures; you cannot store another type of data to them.

The variables **GDB1** through **GDB9** and **GDB0** are restricted to graph databases; you cannot store another type of data to them.

The variables **Str1** through **Str9** and **Str0** are restricted to strings; you cannot store another type of data to them.

Except for system variables, you can store any string of characters, functions, instructions, or variables to the functions Y_n , (1 through 9, and 0), X_{nT}/Y_{nT} (1 through 6), r_n (1 through 6), $u(n)$, $v(n)$, and $w(n)$ directly or through the $Y=$ editor. The validity of the string is determined when the function is evaluated.

Archive Variables

You can store data, programs or any variable from RAM to user data archive memory where they cannot be edited or deleted inadvertently. Archiving also allows you to free up RAM for variables that may require additional memory. The names of archived variables are preceded by an asterisk “*” indicating they are in user data archive.

System Variables

The variables below must be real numbers. You may store to them. Since the TI-83 Plus can update some of them, as the result of a **zoom**, for example, you may want to avoid using these variables to store nongraphing data.

- **Xmin, Xmax, Xscl, ΔX , XFact, Tstep, PlotStart, nMin**, and other window variables.
- **ZXmin, ZXmax, ZXscl, ZTstep, ZPlotStart, Zu(nMin)**, and other **zoom** variables.

The variables below are reserved for use by the TI-83 Plus. You cannot store to them.

n, \bar{x} , Sx , σx , minX, maxX, Σy , Σy^2 , Σxy , a, b, c, RegEQ, x₁, x₂, y₁, z, t, F, χ^2 , \hat{p} , \bar{x}_1 , Sx1, n1, lower, upper, r², R² and other statistical variables.

Statistics Formulas

This section contains statistics formulas for the **Logistic** and **SinReg** regressions, **ANOVA**, **2-SampFTest**, and **2-SampTTest**.

Logistic

The logistic regression algorithm applies nonlinear recursive least-squares techniques to optimize the following cost function:

$$J = \sum_{i=1}^N \left(\frac{c}{1 + ae^{-bx_i}} - y_i \right)^2$$

which is the sum of the squares of the residual errors,

where:
 x = the independent variable list
 y = the dependent variable list
 N = the dimension of the lists

This technique attempts to estimate the constants a , b , and c recursively to make J as small as possible.

SinReg

The sine regression algorithm applies nonlinear recursive least-squares techniques to optimize the following cost function:

$$J = \sum_{i=1}^N [a \sin(bx_i + c) + d - y_i]^2$$

which is the sum of the squares of the residual errors,

where: x = the independent variable list
 y = the dependent variable list
 N = the dimension of the lists

This technique attempts to recursively estimate the constants a , b , c , and d to make J as small as possible.

ANOVA(

The **ANOVA F** statistic is:

$$F = \frac{\text{FactorMS}}{\text{ErrorMS}}$$

The mean squares (*MS*) that make up F are:

$$\text{Factor } MS = \frac{\text{FactorSS}}{\text{Factor}df}$$

$$\text{Error } MS = \frac{\text{ErrorSS}}{\text{Error}df}$$

The sum of squares (*SS*) that make up the mean squares are:

$$\text{Factor } SS = \sum_{i=1}^I n_i(\bar{x}_i - \bar{x})^2$$

$$\text{Error } SS = \sum_{i=1}^I (n_i - 1)Sx_i^2$$

The degrees of freedom *df* that make up the mean squares are:

$$\text{Factor}df = I - 1 = \text{numerator}df \text{ for } F$$

$$\text{Error } df = \sum_{i=1}^I (n_i - 1) = \text{denominator}df \text{ for } F$$

where: I = number of populations
 \bar{x}_i = the mean of each list
 Sx_i = the standard deviation of each list
 n_i = the length of each list
 \bar{x} = the mean of all lists

2-SampFTest

Below is the definition for the **2-SampFTest**.

$Sx1, Sx2$ = Sample standard deviations having n_1-1 and n_2-1 degrees of freedom df , respectively.

$$F = F\text{-statistic} = \left(\frac{Sx1}{Sx2} \right)^2$$

$df(x, n_1-1, n_2-1) = Fpdf()$ with degrees of freedom df , n_1-1 , and n_2-1

p = reported p value

2-SampFTest for the alternative hypothesis $\sigma_1 > \sigma_2$.

$$p = \int_F^{\infty} f(x, n_1 - 1, n_2 - 1) dx$$

2-SampFTest for the alternative hypothesis $\sigma_1 < \sigma_2$.

$$p = \int_0^F f(x, n_1 - 1, n_2 - 1) dx$$

2-SampFTest for the alternative hypothesis $\sigma_1 \neq \sigma_2$. Limits must satisfy the following:

$$\frac{p}{2} = \int_0^{Lbnd} f(x, n_1 - 1, n_2 - 1) dx = \int_{Ubnd}^{\infty} f(x, n_1 - 1, n_2 - 1) dx$$

where: $[Lbnd, Ubnd]$ = lower and upper limits

The F-statistic is used as the bound producing the smallest integral. The remaining bound is selected to achieve the preceding integral's equality relationship.

2-SampTTest

The following is the definition for the **2-SampTTest**. The two-sample t statistic with degrees of freedom df is:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S}$$

where the computation of S and df are dependent on whether the variances are pooled. If the variances are not pooled:

$$S = \sqrt{\frac{Sx_1^2}{n_1} + \frac{Sx_2^2}{n_2}}$$

$$df = \frac{\left(\frac{Sx_1^2}{n_1} + \frac{Sx_2^2}{n_2} \right)^2}{\frac{1}{n_1-1} \left(\frac{Sx_1^2}{n_1} \right)^2 + \frac{1}{n_2-1} \left(\frac{Sx_2^2}{n_2} \right)^2}$$

otherwise:

$$Sx_p = \frac{(n_1 - 1)Sx_1^2 + (n_2 - 1)Sx_2^2}{df}$$

$$S = \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} Sx_p$$

$$df = n_1 + n_2 - 2$$

and Sxp is the pooled variance.

Financial Formulas

This section contains financial formulas for computing time value of money, amortization, cash flow, interest-rate conversions, and days between dates.

Time Value of Money

$$i = [e^{(y \times \ln(x + 1))}] - 1$$

where: $PMT \neq 0$

$$y = C/Y \div P/Y$$

$$x = (.01 \times I\%) \div C/Y$$

C/Y = compounding periods per year

P/Y = payment periods per year

$I\%$ = interest rate per year

$$i = (-FV \div PV)^{(1 \div N)} - 1$$

where: $PMT = 0$

The iteration used to compute i :

$$0 = PV + PMT \times G_i \left[\frac{1 - (1 + i)^{-N}}{i} \right] + FV \times (1 + i)^{-N}$$

$$I\% = 100 \times C/Y \times [e^{(y \times \ln(x+1))} - 1]$$

where: $x = i$
 $y = P/Y \div C/Y$

$$G_i = 1 + i \times k$$

where: $k = 0$ for end-of-period payments
 $k = 1$ for beginning-of-period payments

$$N = \frac{\ln\left(\frac{PMT \times G_i - FV \times i}{PMT \times G_i + PV \times i}\right)}{\ln(1+i)}$$

where: $i \neq 0$

$$N = -(PV + FV) \div PMT$$

where: $i = 0$

$$PMT = \frac{-i}{G_i} \times \left[PV + \frac{PV + FV}{(1+i)^N - 1} \right]$$

where: $i \neq 0$

$$PMT = -(PV + FV) \div N$$

where: $i = 0$

$$PV = \left[\frac{PMT \times G_i}{i} - FV \right] \times \frac{1}{(1+i)^N} - \frac{PMT \times G_i}{i}$$

where: $i \neq 0$

$$PV = -(FV + PMT \times N)$$

where: $i = 0$

$$FV = \frac{PMT \times G_i}{i} - (1+i)^N \times \left(PV + \frac{PMT \times G_i}{i} \right)$$

where: $i \neq 0$

$$FV = -(PV + PMT \times N)$$

where: $i = 0$

Amortization

If computing $bal()$, $pmt2 = npmt$

Let $bal(0) = RND(PV)$

Iterate from $m = 1$ to $pmt2$

$$\begin{cases} I_m = RND[RND12(-i \times bal(m-1))] \\ bal(m) = bal(m-1) - I_m + RND(PMT) \end{cases}$$

then:

$$bal() = bal(pmt2)$$

$$\Sigma Prn() = bal(pmt2) - bal(pmt1)$$

$$\Sigma Int() = (pmt2 - pmt1 + 1) \times RND(PMT) - \Sigma Prn()$$

where:

RND = round the display to the number of decimal places selected

$RND12$ = round to 12 decimal places

Balance, principal, and interest are dependent on the values of **PMT**, **PV**, **I%**, and $pmt1$ and $pmt2$.

Cash Flow

$$npv() = CF_0 + \sum_{j=1}^N CF_j(1+i)^{-S_{j-1}} \frac{(1-(1+i)^{-n_j})}{i}$$

where: $S_j = \begin{cases} \sum_{i=1}^j n_i & j \geq 1 \\ 0 & j = 0 \end{cases}$

Net present value is dependent on the values of the initial cash flow (CF_0), subsequent cash flows (CF_j), frequency of each cash flow (n_j), and the specified interest rate (i).

$$irr() = 100 \times i, \text{ where } i \text{ satisfies } npv() = 0$$

Internal rate of return is dependent on the values of the initial cash flow (CF_0) and subsequent cash flows (CF_j).

$$i = I\% \div 100$$

Interest Rate Conversions

$$\blacktriangleright Eff = 100 \times (e^{CP \times \ln(x + 1)} - 1)$$

where: $x = .01 \times Nom \div CP$

$$\blacktriangleright Nom = 100 \times CP \times [e^{1 \div CP \times \ln(x + 1)} - 1]$$

where: $x = .01 \times Eff$

Eff = effective rate

CP = compounding periods

Nom = nominal rate

Days between Dates

With the **dbd(** function, you can enter or compute a date within the range Jan. 1, 1950, through Dec. 31, 2049.

Actual/actual day-count method (assumes actual number of days per month and actual number of days per year):

$$dbd \text{ (days between dates)} = \text{Number of Days II} - \text{Number of Days I}$$

$$\begin{aligned}\text{Number of Days I} &= (YI - YB) \times 365 \\ &+ (\text{number of days } MB \text{ to } M1) \\ &+ DT1 \\ &+ \frac{(Y1 - YB)}{4}\end{aligned}$$

$$\begin{aligned}\text{Number of Days II} &= (Y2 - YB) \times 365 \\ &+ (\text{number of days } MB \text{ to } M2) \\ &+ DT2 \\ &+ \frac{(Y2 - YB)}{4}\end{aligned}$$

| | | |
|--------|-------|--|
| where: | $M1$ | = month of first date |
| | $DT1$ | = day of first date |
| | $Y1$ | = year of first date |
| | $M2$ | = month of second date |
| | $DT2$ | = day of second date |
| | $Y2$ | = year of second date |
| | MB | = base month (January) |
| | DB | = base day (1) |
| | YB | = base year (first year after leap year) |

Appendix B: General Information

Battery Information

When to Replace the Batteries

The TI-83 Plus uses five batteries: four AAA alkaline batteries and one lithium battery. The lithium battery provides auxiliary power to retain memory while you replace the AAA batteries.

When the battery voltage level drops below a usable level, the TI-83 Plus:

Displays this message when you turn on the unit.

Your batteries
are low.

Recommend
change of
batteries.

Message A

Displays this message when you attempt to download an application.

Batteries
are low.

Change is
required.

Message B

After **Message A** is first displayed, you can expect the batteries to function for about one or two weeks, depending on usage. (This one-week to two-week period is based on tests with alkaline batteries; the performance of other kinds of batteries may vary.)

The low-battery message continues to be displayed each time you turn on the unit until you replace the batteries. If you do not replace the batteries within about two weeks, the calculator may turn off by itself or fail to turn on until you install new batteries.

If **Message B** is displayed, you must to replace the batteries immediately to successfully download an application.

Replace the lithium battery every three or four years.

Effects of Replacing the Batteries

Do not remove both types of batteries (AAA and lithium auxiliary) at the same time. **Do not** allow the batteries to lose power completely. If you follow these guidelines and the steps for replacing batteries, you can replace either type of battery without losing any information in memory.

Battery Precautions

Take these precautions when replacing batteries.

- Do not leave batteries within reach of children
- Do not mix new and used batteries. Do not mix brands (or types within brands) of batteries.
- Do not mix rechargeable and nonrechargeable batteries.
- Install batteries according to polarity (+ and -) diagrams.
- Do not place nonrechargeable batteries in a battery recharger.
- Properly dispose of used batteries immediately. Do not leave them within the reach of children.
- Do not incinerate or dismantle batteries.

Replacing the Batteries

To replace the batteries, follow these steps.

1. Turn off the calculator. Replace the slide cover over the keyboard to avoid inadvertently turning on the calculator. Turn the back of the calculator toward you.
2. Hold the calculator upright, push downward on the latch on the top of the battery cover with your finger, and then pull the cover toward you.

Note: To avoid loss of information stored in memory, you must turn off the calculator. Do not remove the AAA batteries and the lithium battery simultaneously.

3. Replace all four AAA alkaline batteries simultaneously. Or, replace the lithium battery.
 - To replace the AAA alkaline batteries, remove all four discharged AAA batteries and install new ones according to the polarity (+ and -) diagram in the battery compartment.
 - To replace the lithium battery, remove the screw from the lithium-battery cover, and then remove the cover. Install the new battery, + side up. Replace the cover and secure it with the screw. Use a CR1616 or CR1620 (or equivalent) lithium battery.
4. Replace the battery compartment cover. Turn the calculator on and adjust the display contrast, if necessary.

In Case of Difficulty

Handling a Difficulty

To handle a difficulty, follow these steps.

1. If you cannot see anything on the screen, the contrast may need to be adjusted.

To darken the screen, press and release **2nd**, and then press and hold **▲** until the display is sufficiently dark.

To lighten the screen, press and release **2nd**, and then press and hold **▼** until the display is sufficiently light.

2. If an error menu is displayed, follow the steps in Chapter 1. Refer to the [Error Conditions](#) table for details about specific errors, if necessary.
3. If the busy indicator (dotted line) is displayed, a graph or program has been paused; the TI-83 Plus is waiting for input. Press **ENTER** to continue or press **ON** to break.
4. If a checkerboard cursor (■) is displayed, then either you have entered the maximum number of characters in a prompt, or memory is full. If memory is full:

- Press **[2nd] [MEM]** **2** to display the **MEMORY MANAGEMENT DELETE** menu.
 - Select the type of data you want to delete, or select **1:All** for a list of all variables of all types. A screen is displayed listing each variable of the type you selected and the number of bytes each variable is using.
 - Press **▲** and **▼** to move the selection cursor (**►**) next to the item you want to delete, and then press **[DEL]**. (Chapter 18).
5. If the calculator does not seem to work at all, be sure the batteries are fresh and that they are installed properly. Refer to battery information on pages 736 and 737.
 6. If the calculator still doesn't work even though you are sure the batteries are sufficiently charged, you can try the two solutions in the order they are presented.
 - Download calculator system software as follows:
 - a. Remove one battery from the calculator and then press and hold the **[DEL]** key while re-installing the battery. This will force the calculator to accept a download of system software.
 - b. Connect your calculator to a personal computer with the **TI-GRAF LINK™** accessory to download current or new software code to your calculator.

- II. If the above solution does not work, reset all memory as follows:
 - a. Remove one battery from the calculator and then press and hold down the **CLEAR** key while re-installing the battery. While continuing to hold down the **CLEAR** key, press and hold down the **ON** key. When the home screen is displayed, release the keys.
 - b. Press **2nd** **[MEM]** to display the **MEMORY** menu.
 - c. Select **7:Reset** to display the **RAM ARCHIVE ALL** menu.
 - d. Press **▶** **▶** to display the **ALL** menu.
 - e. Select **1:All Memory** to display the **RESET MEMORY** menu.
 - f. To continue with the reset, select **2:Reset**. The message **MEM cleared** is displayed on the home screen.

Error Conditions

When the TI-83 Plus detects an error, it displays **ERR:*message*** and an error menu. Chapter 1 describes the general steps for correcting errors. This table contains each error type, possible causes, and suggestions for correction.

| Error Type | Possible Causes and Suggested Remedies |
|---------------------|--|
| ARCHIVED | You have attempted to use, edit, or delete an archived variable. For example, <code>dim(L1)</code> is an error if L1 is archived. |
| ARCHIVE FULL | You have attempted to archive a variable and there is not enough space in archive to receive it. |
| ARGUMENT | A function or instruction does not have the correct number of arguments. See Appendix A and the appropriate chapter. |
| BAD ADDRESS | You have attempted to send or receive an application and an error (e.g. electrical interference) has occurred in the transmission. |

| Error Type | Possible Causes and Suggested Remedies |
|------------|--|
| BAD GUESS | <ul style="list-style-type: none">In a CALC operation, you specified a Guess that is not between Left Bound and Right Bound.For the solve(function or the equation solver, you specified a <i>guess</i> that is not between <i>lower</i> and <i>upper</i>.Your guess and several points around it are undefined. <p>Examine a graph of the function. If the equation has a solution, change the bounds and/or the initial guess.</p> |
| BOUND | <ul style="list-style-type: none">In a CALC operation or with Select(, you defined Left Bound > Right Bound.In fMin(, fMax(, solve(, or the equation solver, you entered <i>lower</i> \geq <i>upper</i>. |
| BREAK | You pressed the [ON] key to break execution of a program, to halt a DRAW instruction, or to stop evaluation of an expression. |

| Error Type | Possible Causes and Suggested Remedies |
|---------------------|---|
| DATA TYPE | <p>You entered a value or variable that is the wrong data type.</p> <ul style="list-style-type: none">For a function (including implied multiplication) or an instruction, you entered an argument that is an invalid data type, such as a complex number where a real number is required. See Appendix A and the appropriate chapter.In an editor, you entered a type that is not allowed, such as a matrix entered as an element in the stat list editor. See the appropriate chapter.You attempted to store an incorrect data type, such as a matrix, to a list. |
| DIM MISMATCH | <p>You attempted to perform an operation that references more than one list or matrix, but the dimensions do not match.</p> |
| DIVIDE BY 0 | <ul style="list-style-type: none">You attempted to divide by zero. This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph.You attempted a linear regression with a vertical line. |

| Error Type | Possible Causes and Suggested Remedies |
|----------------|---|
| DOMAIN | <ul style="list-style-type: none">• You specified an argument to a function or instruction outside the valid range. This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph. See Appendix A and the appropriate chapter.• You attempted a logarithmic or power regression with a $-X$ or an exponential or power regression with a $-Y$.• You attempted to compute $\Sigma Prn($ or $\Sigma Int($ with $pmt2 < pmt1$. |
| DUPLICATE | <ul style="list-style-type: none">• You attempted to create a duplicate group name. |
| Duplicate Name | <ul style="list-style-type: none">• A variable you attempted to transmit cannot be transmitted because a variable with that name already exists in the receiving unit. |
| EXPIRED | You have attempted to run an application with a limited trial period which has expired. |

| Error Type | Possible Causes and Suggested Remedies |
|---------------|--|
| Error in Xmit | <ul style="list-style-type: none">The TI-83 Plus was unable to transmit an item. Check to see that the cable is firmly connected to both units and that the receiving unit is in receive mode.You pressed ON to break during transmission.You attempted to perform a backup from a TI-82 to a TI-83 Plus.You attempted to transfer data (other than L1 through L6) from a TI-83 Plus to a TI-82.You attempted to transfer L1 through L6 from a TI-83 Plus to a TI-82 without using 5:Lists to TI82 on the LINK SEND menu. |
| ID NOT FOUND | This error occurs when the SendID command is executed but the proper calculator ID cannot be found. |
| ILLEGAL NEST | <ul style="list-style-type: none">You attempted to use an invalid function in an argument to a function, such as seq(within <i>expression</i> for seq(. |
| INCREMENT | <ul style="list-style-type: none">The increment in seq(is 0 or has the wrong sign. This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph.The increment in a For(loop is 0. |

| Error Type | Possible Causes and Suggested Remedies |
|------------|--|
| INVALID | <ul style="list-style-type: none">• You attempted to reference a variable or use a function where it is not valid. For example, Y_n cannot reference Y, Xmin, ΔX, or TblStart.• You attempted to reference a variable or function that was transferred from the TI-82 and is not valid for the TI-83 Plus. For example, you may have transferred Un-1 to the TI-83 Plus from the TI-82 and then tried to reference it.• In Seq mode, you attempted to graph a phase plot without defining both equations of the phase plot.• In Seq mode, you attempted to graph a recursive sequence without having input the correct number of initial conditions.• In Seq mode, you attempted to reference terms other than (n-1) or (n-2).• You attempted to designate a graph style that is invalid within the current graph mode.• You attempted to use Select(without having selected (turned on) at least one xyLine or scatter plot. |

| Error Type | Possible Causes and Suggested Remedies |
|-------------|---|
| INVALID DIM | <ul style="list-style-type: none">• You specified dimensions for an argument that are not appropriate for the operation.• You specified a list dimension as something other than an integer between 1 and 999.• You specified a matrix dimension as something other than an integer between 1 and 99.• You attempted to invert a matrix that is not square. |
| ITERATIONS | <ul style="list-style-type: none">• The solve(function or the equation solver has exceeded the maximum number of permitted iterations. Examine a graph of the function. If the equation has a solution, change the bounds, or the initial guess, or both.• irr(has exceeded the maximum number of permitted iterations.• When computing I%, the maximum number of iterations was exceeded. |
| LABEL | The label in the Goto instruction is not defined with a Lbl instruction in the program. |

| Error Type | Possible Causes and Suggested Remedies |
|------------|--|
| MEMORY | <p>Memory is insufficient to perform the instruction or function. You must delete items from memory (Chapter 18) before executing the instruction or function.</p> <p>Recursive problems return this error; for example, graphing the equation $Y_1=Y_1$.</p> <p>Branching out of an If/Then, For(, While, or Repeat loop with a Goto also can return this error because the End statement that terminates the loop is never reached.</p> |
| MemoryFull | <ul style="list-style-type: none"><li data-bbox="323 458 1097 550">• You are unable to transmit an item because the receiving unit's available memory is insufficient. You may skip the item or exit receive mode.<li data-bbox="323 562 1097 734">• During a memory backup, the receiving unit's available memory is insufficient to receive all items in the sending unit's memory. A message indicates the number of bytes the sending unit must delete to do the memory backup. Delete items and try again. |
| MODE | You attempted to store to a window variable in another graphing mode or to perform an instruction while in the wrong mode; for example, DrawInv in a graphing mode other than Func . |

| Error Type | Possible Causes and Suggested Remedies |
|--------------|--|
| NO SIGN CHNG | <ul style="list-style-type: none"> The solve(function or the equation solver did not detect a sign change. You attempted to compute $I\%$ when FV, (N*PMT), and PV are all ≥ 0, or when FV, (N*PMT), and PV are all ≤ 0. You attempted to compute irr(when neither <i>CList</i> nor <i>CFO</i> is > 0, or when neither <i>CList</i> nor <i>CFO</i> is < 0. |
| NONREAL ANS | <p>In Real mode, the result of a calculation yielded a complex result. This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph.</p> |
| OVERFLOW | <p>You attempted to enter, or you have calculated, a number that is beyond the range of the calculator. This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph.</p> |
| RESERVED | <p>You attempted to use a system variable inappropriately. See Appendix A.</p> |
| SINGULAR MAT | <ul style="list-style-type: none"> A singular matrix (determinant = 0) is not valid as the argument for $^{-1}$. The SinReg instruction or a polynomial regression generated a singular matrix (determinant = 0) because it could not find a solution, or a solution does not exist. |
| | <p>This error is not returned during graphing. The TI-83 Plus allows for undefined values on a graph.</p> |

| Error Type | Possible Causes and Suggested Remedies |
|-------------|--|
| SINGULARITY | <i>expression</i> in the solve(function or the equation solver contains a singularity (a point at which the function is not defined). Examine a graph of the function. If the equation has a solution, change the bounds or the initial guess or both. |
| STAT | <p>You attempted a stat calculation with lists that are not appropriate.</p> <ul style="list-style-type: none"> • Statistical analyses must have at least two data points. • Med-Med must have at least three points in each partition. • When you use a frequency list, its elements must be ≥ 0. • $(\text{Xmax} - \text{Xmin}) / \text{Xscl}$ must be ≤ 47 for a histogram. |
| STAT PLOT | You attempted to display a graph when a stat plot that uses an undefined list is turned on. |
| SYNTAX | The command contains a syntax error. Look for misplaced functions, arguments, parentheses, or commas. See Appendix A and the appropriate chapter. |
| TOL NOT MET | You requested a tolerance to which the algorithm cannot return an accurate result. |

| Error Type | Possible Causes and Suggested Remedies |
|------------|---|
| UNDEFINED | You referenced a variable that is not currently defined. For example, you referenced a stat variable when there is no current calculation because a list has been edited, or you referenced a variable when the variable is not valid for the current calculation, such as a after Med-Med . |
| VALIDATION | Electrical interference caused a link to fail or this calculator is not authorized to run the application. |
| VARIABLE | You have tried to archive a variable that cannot be archived or you have tried to unarchive an application or group. Examples of variables that cannot be archived include: <ul style="list-style-type: none">• Real numbers LRESID, R, T, X, Y, Theta, Statistic variables under Vars, STATISTICS menu, Yvars, and the ApplIdList. |
| VERSION | You have attempted to receive an incompatible variable version from another calculator. |

| Error Type | Possible Causes and Suggested Remedies |
|--------------|--|
| WINDOW RANGE | <p>A problem exists with the window variables.</p> <ul style="list-style-type: none">• You defined Xmax ≤ Xmin or Ymax ≤ Ymin.• You defined θmax ≤ θmin and θstep > 0 (or vice versa).• You attempted to define Tstep=0.• You defined Tmax ≤ Tmin and Tstep > 0 (or vice versa).• Window variables are too small or too large to graph correctly. You may have attempted to zoom in or zoom out to a point that exceeds the TI-83 Plus's numerical range. |
| ZOOM | <ul style="list-style-type: none">• A point or a line, instead of a box, is defined in ZBox.• A zoom operation returned a math error. |

Accuracy Information

Computational Accuracy

To maximize accuracy, the TI-83 Plus carries more digits internally than it displays. Values are stored in memory using up to 14 digits with a two-digit exponent.

- You can store a value in the window variables using up to 10 digits (12 for **Xscl**, **Yscl**, **Tstep**, and **θstep**).
- Displayed values are rounded as specified by the mode setting with a maximum of 10 digits and a two-digit exponent.
- **RegEQ** displays up to 14 digits in **Float** mode. Using a fixed-decimal setting other than **Float** causes **RegEQ** results to be rounded and stored with the specified number of decimal places.

Xmin is the center of the leftmost pixel, **Xmax** is the center of the next-to-the-rightmost pixel. (The rightmost pixel is reserved for the busy indicator.) ΔX is the distance between the centers of two adjacent pixels.

- In **Full** screen mode, ΔX is calculated as $(X_{\text{max}} - X_{\text{min}}) / 94$. In **G-T** split-screen mode, ΔX is calculated as $(X_{\text{max}} - X_{\text{min}}) / 46$.
- If you enter a value for ΔX from the home screen or a program in **Full** screen mode, **Xmax** is calculated as $X_{\text{min}} + \Delta X * 94$. In **G-T** split-screen mode, **Xmax** is calculated as $X_{\text{min}} + \Delta X * 46$.

Ymin is the center of the next-to-the-bottom pixel; **Ymax** is the center of the top pixel. ΔY is the distance between the centers of two adjacent pixels.

- In **Full** screen mode, ΔY is calculated as $(Y_{\text{max}} - Y_{\text{min}}) / 62$. In **Horiz** split-screen mode, ΔY is calculated as $(Y_{\text{max}} - Y_{\text{min}}) / 30$. In **G-T** split-screen mode, ΔY is calculated as $(Y_{\text{max}} - Y_{\text{min}}) / 50$.
- If you enter a value for ΔY from the home screen or a program in **Full** screen mode, **Ymax** is calculated as $Y_{\text{min}} + \Delta Y * 62$. In **Horiz** split-screen mode, **Ymax** is calculated as $Y_{\text{min}} + \Delta Y * 30$. In **G-T** split-screen mode, **Ymax** is calculated as $Y_{\text{min}} + \Delta Y * 50$.

Cursor coordinates are displayed as eight-character numbers (which may include a negative sign, decimal point, and exponent) when **Float** mode is selected. **X** and **Y** are updated with a maximum accuracy of eight digits.

minimum and **maximum** on the **CALCULATE** menu are calculated with a tolerance of $1E-5$; $\int f(x)dx$ is calculated at $1E-3$. Therefore, the result displayed may not be accurate to all eight displayed digits. For most functions, at least five accurate digits exist. For **fMin(**, **fMax(**, and **fNInt(** on the **MATH** menu and **solve(** in the **CATALOG**, the tolerance can be specified.

Function Limits

| Function | Range of Input Values |
|----------------------------|--|
| $\sin x, \cos x, \tan x$ | $0 \leq x < 10^{12}$ (radian or degree) |
| $\sin^{-1} x, \cos^{-1} x$ | $-1 \leq x \leq 1$ |
| $\ln x, \log x$ | $10^{-100} < x < 10^{100}$ |
| e^x | $-10^{100} < x \leq 230.25850929940$ |
| 10^x | $-10^{100} < x < 100$ |
| $\sinh x, \cosh x$ | $ x \leq 230.25850929940$ |
| $\tanh x$ | $ x < 10^{100}$ |
| $\sinh^{-1} x$ | $ x < 5 \times 10^{99}$ |
| $\cosh^{-1} x$ | $1 \leq x < 5 \times 10^{99}$ |
| $\tanh^{-1} x$ | $-1 < x < 1$ |
| \sqrt{x} (real mode) | $0 \leq x < 10^{100}$ |
| \sqrt{x} (complex mode) | $ x < 10^{100}$ |
| $x!$ | $-.5 \leq x \leq 69$, where x is a multiple of .5 |

Function Results

| Function | Range of Result |
|-------------------------------|---|
| $\sin^{-1} x$, $\tan^{-1} x$ | -90° to 90° or $-\pi/2$ to $\pi/2$ (radians) |
| $\cos^{-1} x$ | 0° to 180° or 0 to π (radians) |

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Product Support

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For general questions, contact Texas Instruments Customer Support:

phone: **1-800-TI-CARES (1-800-842-2737)**

e-mail: **ti-cares@ti.com**

For technical questions, call the Programming Assistance Group of Customer Support:

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Contact TI by e-mail or visit the TI calculator home page on the World Wide Web.

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Warranty Coverage. This TI electronic product is warranted against defective materials and construction. **THIS WARRANTY IS VOID IF THE PRODUCT HAS BEEN DAMAGED BY ACCIDENT OR UNREASONABLE USE, NEGLECT, IMPROPER SERVICE, OR OTHER CAUSES NOT ARISING OUT OF DEFECTS IN MATERIALS OR CONSTRUCTION.**

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Warranty Performance. During the above one (1) year warranty period, your defective product will be either repaired or replaced with a reconditioned model of an equivalent quality (at TI's option) when the product is returned, postage prepaid, to Texas Instruments Service Facility. The warranty of the repaired or replacement unit will continue for the warranty of the original unit or six (6) months, whichever is longer. Other than the postage requirement, no charge will be made for such repair and/or replacement. TI strongly recommends that you insure the product for value prior to mailing.

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Index

- ! (factorial), 94, 692
- " " (string indicator), 484
- " (seconds notation), 97, 697
- I% (annual interest rate variable), 444, 462
- ° (degrees notation), 692
- / (division), 63, 696
- E (exponent), 14, 20, 661
- ◊ (graph style, animate), 117
- (graph style, dot), 117
- \\ (graph style, line), 117
- ≥ (greater than or equal to), 101, 694
- ≤ (less than or equal to), 101, 694
- * (multiplication), 63, 695
- (negation), 49, 66, 695
- ≠ (not equal to), 101, 694
- N (number of payment periods variable), 444, 462
- π (pi), 66
- (plot type, box), 371
- (plot type, histogram), 370
- (plot type, modified box), 370
- ◀ (plot type, normal probability), 372
- (subtraction), 63, 696
- L (user-created list name symbol), 309, 668
- Store, 29, 686
- √ (square root), 64, 695
- , • (pixel mark), 235, 373
- ⁻¹ (inverse), 64, 271, 694
- χ²-Test (chi-square test), 412, 657
- χ²cdf((chi-square cdf), 429, 657
- χ²pdf((chi-square pdf), 428, 657
- Fcdf(, 430, 662
- Dec (to decimal conversion), 67, 659
- dim((assign dimension), 275, 301, 660
- LDIST, 471
- DMS (to degrees/minutes/seconds), 99, 661
- LDREF, 471
- Eff((to effective interest rate), 459, 662
- if(x)dx operation on a graph, 153
- Frac (to fraction), 67, 664
- ΣInt((sum of interest), 455, 668
- LLIGHT, 471
- ΔList(, 303, 669
- LLREF, 471
- Nom((to nominal interest rate), 459, 672
- Fpdf(, 429, 664
- Polar (to polar), 91, 675
- ΣPrn((sum of principal), 455, 676

►Rect (to rectangular), 91, 679
*row(, 282, 680
*row+(, 282, 680
ΔTbl (table step variable), 205
LTEMP, 471
LTREF, 471
LVOLT, 471
LVREF, 471
ΔX window variable, 124
ΔY window variable, 124
' (minutes notation), 97, 697
() (parentheses), 48
+ (addition), 63, 696
+ (concatenation), 490, 696
+ (pixel mark), 235, 373
: (colon), 504
< (less than), 101, 694
= (equal-to relational test), 101, 693
> (greater than), 101, 694
[] (matrix indicator), 265
^ (power), 64, 695
{ } (list indicator), 288
1-PropZInt (one-proportion z confidence interval), 410, 676
1-PropZTest (one-proportion z test), 402, 676
1-Var Stats (one-variable statistics), 357, 689
10^((power of ten), 65, 695
² (square), 64, 694

2-PropZInt (two-proportion z confidence interval), 411, 676
2-PropZTest (two-proportion z test), 403, 677
2-SampFTest (two-sample F-Test), 414, 681
2-SampTInt (two-sample t confidence interval), 408, 681
2-SampTTest (two-sample t test), 400, 682
2-SampZInt (two-sample z confidence interval), 407, 682
2-SampZTest (two-sample z test), 399, 682
2-Var Stats (two-variable statistics), 358, 689
³ (cube), 68, 693
 $\sqrt[3]{}$ (cube root), 68, 693

—A—

a+bi (rectangular complex mode), 24, 84, 656
about, 596
above graph style($\overline{\text{A}}$), 117
abs((absolute value), 79, 90, 271, 655
accuracy information
computational and graphing, 754
function limits and results, 756
graphing, 132

- addition (+), 63, 696
alpha cursor, 12
alpha-lock, 18
alternative hypothesis, 391
amortization
 $\Sigma\text{Int}()$ (sum of interest), 455, 668
 $\Sigma\text{Prn}()$ (sum of principal), 455, 676
 bal(amortization balance), 454, 656
 calculating schedules, 454
 formula, 731
and (Boolean operator), 103, 655
ANGLE menu, 97
angle modes, 22
angle(, 90, 655
animate graph style (◊), 117
ANOVA((one-way variance analysis), 417, 655
 formula, 722
Ans (last answer), 36, 599, 655
APD (Automatic Power Down), 6
applications. *See examples*, applications
Apps, 27, 598
AppVars, 27, 598
arccosine ($\cos^{-1}()$), 63
Archive, 30, 610, 655
 archive full error, 628, 742
 garbage collection, 623
 memory error, 623
archived variables, 719
arcsine ($\sin^{-1}()$), 63
arctangent ($\tan^{-1}()$), 63
Asm(, 537, 655
AsmComp(, 537, 655
AsmPrgm(, 537, 655
assembly language programs, 537
augment(, 277, 307, 656
Automatic Power Down (APD), 6
automatic regression equation, 353
automatic residual list (RESID), 352
axes format, sequence graphing, 187
axes, displaying (AxesOn, AxesOff), 127, 656
AxesOff, 127, 656
AxesOn, 127, 656

—B—

- backing up calculator memory, 638, 650
bal(amortization balance), 454, 656
bar, 468
batteries, 7, 735
below graph style (◊), 117
binomcdf(, 431, 656
binompdf(, 430, 656
block, 623
Boolean logic, 103
box pixel mark (□), 235, 373

Boxplot plot type (甘), 371

busy indicator, 11

—C—

C/Y (compounding-periods-per-year variable), 444, 463

CALCULATE menu, 147

Calculate output option, 388, 392

cash flow

calculating, 452

formula, 732

irr((internal rate of return), 453, 668

npv((net present value), 453, 673

CATALOG, 481

CBL 2/CBL, 464

CBL/CBR

Quitting, 480

Running, 464

Selecting, 464

CBL/CBR APP menu, 467

CBR, 464, 533, 633, 665

check memory, 596

chi-square cdf ($\chi^2\text{cdf}()$), 429, 657

chi-square pdf ($\chi^2\text{pdf}()$), 428, 657

chi-square test ($\chi^2\text{-Test}$), 412, 657

Circle((draw circle), 228, 657

Clear Entries, 596, 657

clearing

all lists (**ClrAllLists**), 596, 657

drawing (**ClrDraw**), 217, 657

entries (**Clear Entries**), 596, 657

home screen (**ClrHome**), 532, 657

list (**ClrList**), 349, 658

table (**ClrTable**), 532, 658

ClrAllLists (clear all lists), 596, 657

ClrDraw (clear drawing), 217, 657

ClrHome (clear home screen), 532, 657

ClrList (clear list), 349, 658

ClrTable (clear table), 532, 658

coefficients of determination (r^2 , R^2 , 354)

colon separator (:), 504

combinations (**nCr**), 93, 672

compiling an assembly program, 537, 655

complex

modes (**a+bi**, $re^{\theta i}$), 24, 84, 656, 679

numbers, 24, 84, 679

compounding-periods-per-year variable (**C/Y**), 444, 463

concatenation (+), 490, 696

confidence intervals, 392

conj((conjugate), 88, 658

Connected (plotting mode), 23, 658

connecting two calculators, 633

contrast (display), 8

convergence, sequence graphing, 195

conversions

►Dec (to decimal), 67, 659
►DMS (to degrees/minutes/ seconds), 99, 661
►Eff (to effective interest rate), 459
►Frac (to fraction conversion), 67, 664
►Nom (to nominal interest rate conversion), 459, 672
►Polar (to polar conversion), 91, 675
►Rect (to rectangular conversion), 91, 679
Equ»String((equation-to-string conversion), 491, 662
List»matr((list-to-matrix conversion), 279, 308, 670
Matr»list((matrix-to-list conversion), 278, 308, 670
P»Rx(, P»Ry((polar-to-rectangular conversion), 100, 678
R»Pr(, R»Pθ((rectangular-to-polar conversion), 100, 681
String»Equ((string-to-equation conversion), 493, 686
CoordOff, 126, 658
CoordOn, 126, 658
correlation coefficient (*r*), 354
cos⁻¹((arccosine), 63, 658
cos((cosine), 63, 658
cosh⁻¹((hyperbolic arccosine), 496, 658
cosh((hyperbolic cosine), 496, 658

cosine (**cos()**), 63, 658
cross pixel mark (+), 235, 373
cube (³), 68, 693
cube root (³√()), 68, 693
cubic regression (**CubicReg**), 359, 658
CubicReg (cubic regression), 359, 658
cumSum((cumulative sum), 279, 303, 659
cumulative sum (**cumSum()**), 279, 303, 659
cursors, 12, 18

—D—

data collection
methods, 468
options, 468
results, 471
starting & stopping, 479
Data input option, 388, 390
data logger, 473
data points, 475
data results, 471
days between dates (**dbd()**), 460, 659, 733
dbd((days between dates), 460, 659, 733
decimal mode (float or fixed), 21
decrement and skip (**DS<()**), 521, 661
definite integral, 70, 152, 165

defragmenting, 622
Degree angle mode, 22, 97, 659
degrees notation ($^{\circ}$), 98, 692
delete variable contents (**DelVar**), 523,
 659
deleting items from memory, 599
DelVar (delete variable contents), 659
DependAsk, 206, 209, 659
DependAuto, 206, 209, 659
derivative. *See* numerical derivative
det((determinant), 275, 659
determinant (**det**), 275, 659
DiagnosticOff, 354, 660
DiagnosticOn, 354, 660
diagnostics display mode(**r r², R²**), 354
differentiation, 72, 152, 165, 175
dim((dimension), 275, 301, 660
dimensioning a list or matrix, 275, 301,
 660
directions, 471
DIRECTNS, 471
Disp (display), 528, 529, 660
DispGraph (display graph), 530, 660
display contrast, 8
display cursors, 12
DispTable (display table), 530, 661
DISTR (distributions menu), 424
DISTR DRAW (distributions drawing
 menu), 434
distribution functions
 $\chi^2\text{cdf}$ (, 429, 657
 $\chi^2\text{pdf}$ (, 428, 657
Fcdf(, 430, 662
Fpdf(, 429, 664
binomcdf(, 431, 656
binompdf(, 430, 656
geometcdf(, 433, 665
geometpdf(, 433, 665
invNorm(, 426, 668
normalcdf(, 426, 672
normalpdf(, 425, 673
poissoncdf(, 432, 675
poissonpdf(, 432, 675
tcdf(, 427, 687
tpdf(, 427, 687
distribution shading instructions
ShadeF(, 437, 684
Shade χ^2 (, 436, 684
Shade_t(, 435, 684
ShadeNorm(, 435, 684
division (/), 63, 696
DMS (degrees/minutes/seconds entry
 notation), 97, 697
Dot (plotting mode), 23, 661
dot graph style ('.), 117
dot pixel mark (•), 235, 373
dr/dθ operation on a graph, 175
DRAW menu, 214
Draw output option, 388, 392
DRAW POINTS menu, 233

DRAW STO (draw store menu), 239
DrawF (draw a function), 224, 661
drawing on a graph
 circles (**Circle()**), 228
 line segments (**Line()**), 218
 lines (**Horizontal**, **Line(**, **Vertical**),
 221
 pixels (**Pxl-Change**, **Pxl-Off**, **Pxl-On**,
 pxl-Test), 237
 points (**Pt-Change**, **Pt-Off**, **Pt-On**),
 233
 tangents (**Tangent**), 222
 text (**Text**), 230
 using **Pen**, 232
DrawInv (draw inverse), 224, 661
DS<((decrement and skip), 521, 661
DuplicateName menu, 644
dx/dt operation on a graph, 152, 165
dy/dx operation on a graph, 152, 165,
 175

—E—

e (constant), 65
e^a((exponential), 65, 661
edit keys table, 17
Else, 514
End, 476, 515, 662
Eng (engineering notation mode), 20,
 662

ENTRY (last entry key), 33
entry cursor, 12
EOS (Equation Operating System), 47
eqn (equation variable), 72
Equ►String((equation-to-string
 conversion), 491, 662
equal-to relational test (=), 101, 693
Equation Operating System (EOS), 47
Equation Solver, 72
equations with multiple roots, 77
errors
 diagnosing and correcting, 59
 messages, 742
examples—applications
 area between curves, 578
 areas of regular n-sided polygons,
 588
 box plots, 560
 box with lid, 546
 defining a, 546
 defining a table of values, 547
 finding calculated maximum, 557
 setting the viewing window, 551
 tracing the graph, 553
 zooming in on the graph, 555
 zooming in on the table, 549
 cobweb attractors, 572
 fundamental theorem of calculus,
 584
 guess the coefficients, 574

- inequalities, 566
mortgage payments, 592
parametric equations, ferris wheel problem, 580
piecewise functions, 564
quadratic formula
 converting to a fraction, 542
 displaying complex results, 544
 entering a calculation, 540
Sierpinski triangle, 570
solving a system of nonlinear equations, 568
unit circle and trig curves, 576
- examples—Getting Started
 coin flip, 61
 compound interest, 442
 drawing a tangent line, 212
 financing a car, 440
 forest and trees, 176
 generating a sequence, 283
 graphing a circle, 105
 mean height of a population, 381
 path of a ball, 154
 pendulum lengths and periods, 315
 polar rose, 166
 roots of a function, 203
 sending variables, 629
 solving a system of linear equations, 256
 unit circle, 246
- volume of a cylinder, 497
examples—miscellaneous
 calculating outstanding loan balances, 456
 convergence, 195
 daylight hours in Alaska, 363
 predator-prey model, 197
exponential regression (**ExpReg**), 361, 662
expr((string-to-expression conversion), 491, 662
ExpReg (exponential regression), 361, 662
expression, 13
 converting from string (**expr()**, 491, 662
 turning on and off (**ExprOn**, 128, 662
ExprOff (expression off), 128, 662
ExprOn (expression on), 128, 662

—F—

- factorial (!), 94, 692
family of curves, 131
Fill, 276, 663
FINANCE CALC menu, 446
FINANCE VARS menu, 462
financial functions
 amortization schedules, 454

- cash flows, 452
- days between dates, 460
- interest rate conversions, 459
- payment method, 461
- time value of money (TVM), 448
- Fix** (fixed-decimal mode), 21, 663
- fixed-decimal mode (**Fix**), 21, 663
- Float** (floating-decimal mode), 21, 663
- floating-decimal mode (**Float**), 21, 663
- fMax(** (function maximum), 69, 663
- fMin(** (function minimum), 69, 663
- fInt(** (function integral), 71, 663
- FnOff** (function off), 115, 663
- FnOn** (function on), 115, 664
- For(**, 515, 664
- format settings, 125, 187
- formulas
 - amortization, 731
 - ANOVA, 722
 - cash flow, 732
 - days between dates, 733
 - factorial, 94
 - interest rate conversions, 733
 - logistic regression, 721
 - sine regression, 722
 - time value of money, 728
 - two-sample F-Test, 724
 - two-sample *t* test, 726
- fPart(** (fractional part), 80, 273, 664
- free-moving cursor, 132
- frequency, 357
- Full** (full-screen mode), 25, 664
- full-screen mode (**Full**), 25, 664
- Func** (function graphing mode), 23, 664
- function graphing
 - ΔX and ΔY window variables, 124
 - accuracy, 132
 - CALC (calculate menu), 147
 - defining and displaying, 107
 - defining in the $Y=$ editor, 111
 - defining on the home screen, in a program, 112
 - deselecting, 114, 115
 - displaying, 108, 121, 129
 - evaluating, 113
 - family of curves, 131
 - format settings, 125
 - free-moving cursor, 132
 - graph styles, 117
 - maximum of (**fMax()**, 69, 663
 - minimum of (**fMin()**, 663
 - modes, 23, 109, 664
 - moving the cursor to a value, 135
 - overlaying functions on a graph, 130
 - panning, 136
 - pausing or stopping a graph, 129
 - Quick Zoom, 136
 - selecting, 114, 115, 664
 - shading, 119

Smart Graph, 129
tracing, 134
viewing window, 121
window variables, 121, 122, 123
 Y= editor, 111
ZOOM MEMORY menu, 144
ZOOM menu, 138
function integral (**fInt()**, 71, 663
function, definition of, 15
functions and instructions table, 654
future value, 444, 451
FV (future-value variable), 444, 462

—G—

G-T (graph-table split-screen mode), 25, 252, 666
garbage collecting, 622
GarbageCollect, 626, 664
Gauge, 468
gcd (greatest common divisor), 82, 665
GDB (graph database), 242
geometcdf, 433, 665
geometpdf, 433, 665
Get (get data from CBL 2/CBL or CBR), 533, 665
GetCalc (get data from TI-83), 533, 665
getKey, 531, 665

Getting Started. *See examples, Getting Started*
Goto, 519, 665
graph database (GDB), 242
graph styles, 117
graphing modes, 23
graphing-order modes, 24
GraphStyle, 524, 665
graph-table split-screen mode (**G-T**), 25, 252, 666
greater than ($>$), 101, 694
greater than or equal to (\geq), 101, 694
greatest common divisor (**gcd**), 82, 665
greatest integer (**int**), 81, 273, 668
GridOff, 127, 666
GridOn, 127, 666
grouping, 616

—H—

Histogram plot type (**ht**), 370
home screen, 10
Horiz (horizontal split-screen mode), 25, 250, 666
Horizontal (draw line), 221, 666
hyperbolic functions, 495
hypothesis tests, 396

—I—

i (complex number constant), 86

- identity(**, 277, 666
- If** instructions
 If, 512, 666
 If-Then, 513, 666
 If-Then-Else, 514, 667
- imag(** (imaginary part), 89, 667
- imaginary part (**imag()**), 89, 667
- implied multiplication, 48
- increment and skip (**IS>()**), 520, 668
- independent variable, 206, 209, 667
- IndptAsk**, 206, 209, 667
- IndptAuto**, 206, 209, 667
- inferential stat editors, 388
- inferential statistics. *See* stat tests;
 confidence intervals
 alternative hypotheses, 391
 bypassing editors, 393
 calculating test results (**Calculate**),
 392
 confidence interval calculations, 392
 data input or stats input, 390
 entering argument values, 390
 graphing test results (**Draw**), 392
 input descriptions table, 419
 pooled option, 391
 STAT TESTS menu, 394
 test and interval output variables,
 422
- Input**, 526, 527, 667
- insert cursor, 12
- inString(** (in string), 492, 667
- instruction, definition of, 16
- int(** (greatest integer), 81, 273, 668
- integer part (**iPart()**), 80, 273, 668
- integral. *See* numerical integral
- interest rate conversions
 ►**Eff(** (compute effective interest
 rate), 459
 ►**Nom(** (compute nominal interest
 rate), 459
 calculating, 459
 formula, 733
- internal rate of return (**irr()**), 453, 668
- intersect** operation on a graph, 151
- INTRVL (SEC)**, 475
- inverse (${}^{\text{-}1}$), 64, 271, 694
- inverse cumulative normal distribution
 invNorm(), 426, 668
- inverse trig functions, 63
- invNorm(** (inverse cumulative normal
 distribution), 426, 668
- iPart(** (integer part), 80, 273, 668
- irr(** (internal rate of return), 453, 668
- IS>** (increment and skip), 520, 668

—K—

- keyboard
 layout, 2
 math operations, 63

key-code diagram, 532

—L—

LabelOff, 127, 668

LabelOn, 127, 668

labels

graph, 127, 668

program, 519, 669

Last Entry, 33

Lbl (label), 519, 669

lcm((least common multiple), 82, 669

least common multiple (**lcm**()), 82, 669

length(of string, 492, 669

less than (**<**), 101, 694

less than or equal to (**≤**), 101, 694

Light-Time, 468

line graph style (****), 117

line segments, drawing, 218

Line((draw line), 220, 669

lines, drawing, 220, 221

LINK RECEIVE menu, 644

LINK SEND menu, 634

linking

receiving items, 644

to a CBL 2/CBL or CBR, 633

to a PC or Macintosh, 633

to a TI-82, 641, 646

transmitting items, 629

two TI-83 Plus units, 638

LinReg(a+bx) (linear regression), 360, 669

LinReg(ax+b) (linear regression), 359, 669

LinRegTTest (linear regression *t* test), 415, 669

LIST MATH menu, 311

LIST NAMES menu, 291

LIST OPS menu, 299

ListMatr((lists-to-matrix conversion), 279, 308, 670

lists

accessing an element, 289

attaching formulas, 293, 294, 336

clearing all elements, 333

copying, 289

creating, 286, 332

deleting from memory, 289, 599

detaching formulas, 296, 340

dimension, 288

entering list names, 292, 330

indicator (**{ }**), 288

naming lists, 286

storing and displaying, 288

transmitting to and from TI-73, 642

transmitting to and from TI-82, 641, 646

using in expressions, 297

using to graph a family of curves, 131, 290

using to select data points from a plot, 305
using with math operations, 63, 298
In(, 65, 670
LnReg (logarithmic regression), 360, 670
log(, 65, 670
logic (Boolean) operators, 103
Logistic (regression), 361, 670
logistic regression formula, 721

—M—

marked for deletion, 623
MATH CPX (complex menu), 88
MATH menu, 67
MATH NUM (number menu), 79
math operations, 63
MATH PRB (probability menu), 92
Matrlst((matrix-to-list conversion), 278, 308, 670
matrices
 accessing elements, 268
 copying, 267
 defined, 258
 deleting from memory, 261
 dimensions, 259, 275, 276
 displaying a matrix, 267
 displaying matrix elements, 260
 editing matrix elements, 262

indicator ([]), 265
inverse ($^{-1}$), 271
math functions, 269
matrix math functions (**det(**, **T**, **dim(**, **Fill(**, **identity(**, **randM(**, **augment(**, **Matrlst(**, **List→matr(**, **cumSum(**, 274
referencing in expressions, 265
relational operations, 272
row operations(**ref(**, **rref(**, **rowSwap(**, **row+(**, ***row(**, ***row+(**), 280
selecting, 258
viewing, 261
MATRX EDIT menu, 258
MATRX MATH menu, 274
MATRX NAMES menu, 265
max, 470
max((maximum), 81, 311, 670
maximum of a function (**fMax(**), 69, 663
maximum operation on a graph, 150
mean(, 312, 671
Med-Med (median-median), 358, 671
median(, 312, 671
Mem Mgmt/Del menu, 597
memory
 backing up, 650
 checking available, 596
 clearing all list elements from, 602
 clearing entries from, 601
 deleting items from, 599

- error, 626
insufficient during transmission, 653
resetting defaults, 604
resetting memory, 604
MEMORY menu, 596
Menu((define menu), 521, 671
menus, 39, 40
 defining (**Menu()**), 521, 671
 map, 698
 scrolling, 41
meter, 468
min, 470
min((minimum), 81, 311, 671
minimum of a function (**fMin()**), 69, 663
minimum operation on a graph, 150
minutes notation ('), 97, 697
ModBoxplot plot type (, 370
mode settings, 19
a+bi (complex rectangular), 24, 84,
 656
Connected (plotting), 23, 658
Degree (angle), 22, 99, 659
Dot (plotting), 23, 661
Eng (notation), 20, 662
Fix (decimal), 21, 663
Float (decimal), 21, 663
Full (screen), 25, 664
Func (graphing), 23, 664
G-T (screen), 25, 666
Horiz (screen), 25, 666
Normal (notation), 20, 672
Par/Param (graphing), 23, 674
Pol/Polar (graphing), 23, 675
Radian (angle), 22, 99, 678
 $re^{\theta}i$ (complex polar), 24, 84, 679
Real, 24, 679
Sci (notation), 20, 683
Seq (graphing), 23, 683
Sequential (graphing order), 24, 683
Simul (graphing order), 24, 685
modified box plot type (, 370
multiple entries on a line, 14
multiplication (*), 63, 695
multiplicative inverse, 64
- N—**
- nCr** (number of combinations), 93, 672
nDeriv((numerical derivative), 70, 672
negation (-), 49, 66, 695
nonrecursive sequences, 182
normal distribution probability
 (**normalcdf()**), 426, 672
Normal notation mode, 20, 672
normal probability plot type (, 372
normalcdf((normal distribution
 probability), 426, 672
normalpdf((probability density
 function), 425, 673
NormProbPlot plot type (, 372

not equal to (\neq), 101, 694
not (Boolean operator), 104, 673
nPr (permutations), 93, 673
npv (net present value), 453, 673
numerical derivative, 70, 152, 165, 175
numerical integral, 70, 153

—O—

Omit, 619, 645
ON/HALT, 480
one-proportion z confidence interval
 (**1-PropZInt**), 410, 676
one-proportion z test (**1-PropZTest**),
 402, 676
one-sample t confidence interval
 (**TInterval**), 406, 687
one-variable statistics (**1-Var Stats**),
 357, 689
or (Boolean) operator, 103, 673
order of evaluating equations, 47
Output(), 255, 530, 673
Overwrite, 619, 645
Overwrite All, 619

—P—

P>Rx(, **P Ry**((polar-to-rectangular
 conversions), 100, 678
P/Y (number-of-payment-periods-per-
 year variable), 444, 463

panning, 136
Par/Param (parametric graphing mode),
 23, 674
parametric equations, 159
parametric graphing
 CALC (calculate operations on a
 graph), 165
 defining and editing, 158, 159
 free-moving cursor, 163
 graph format, 161
 graph styles, 159
 moving the cursor to a value, 164
 selecting and deselecting, 160
 setting parametric mode, 158
 tracing, 163
 window variables, 160
Y= editor, 158
zoom operations, 165
parentheses, 48
path (\downarrow) graph style, 117
Pause, 518, 674
pausing a graph, 129
Pen, 232
permutations (**nPr**), 93, 673
phase plots, 197
 Pi (π), 66
Pic (pictures), 239
pictures (**Pic**), 239
pixel, 237
pixels in **Horiz/G-T** modes, 238, 254

PLOT, 476
Plot1(, 373, 674
Plot2(, 373, 674
Plot3(, 373, 674
PlotsOff, 375, 675
PlotsOn, 375, 675
plotting modes, 23
plotting stat data, 368
PMT (payment amount variable), 444, 462
Pmt_Bgn (payment beginning variable), 461, 675
Pmt_End (payment end variable), 461, 675
poissoncdf(, 432, 675
poissonpdf(, 432, 675
Pol/Polar (polar graphing mode), 23, 168, 675
polar equations, 169
polar form, complex numbers, 87
polar graphing
 CALC (calculate operations on a graph), 175
 defining and displaying, 168
 equations, 169
 free-moving cursor, 173
 graph format, 171
 graph styles, 169
 mode (**Pol/Polar**), 23, 168, 675
 moving the cursor to a value, 174
selecting and deselecting, 169
tracing, 173
window variables, 170
Y= editor, 168
ZOOM operations, 174
PolarGC (polar graphing coordinates), 126, 676
pooled option, 388, 391
power (^), 64, 695
power of ten (**10^()**), 65, 695
present value, 444, 450
previous entry (Last Entry), 33
prgm (program name), 522, 676
PRGM CTL (program control menu), 511
PRGM EDIT menu, 510
PRGM EXEC menu, 510
PRGM I/O (Input/Output menu), 525
PRGM NEW menu, 500
probability, 92
probability density function
 (**normalpdf()**), 425, 673
probe, 468
prod((product), 313, 676
programming
 copying and renaming, 509
 creating new, 500
 defined, 500
 deleting, 501
 deleting command lines, 508

editing, 507
entering command lines, 504
executing, 505
inserting command lines, 508
instructions, 511
name (**prgm**), 522, 676
renaming, 509
running assembly language
 program, 537
stopping, 506
subroutines, 535
Prompt, 528, 676
Pt-Change(, 235, 677
Pt-Off(, 234, 677
Pt-On(, 233, 677
PV (present value variable), 444, 462
p-value, 422
PwrReg (power regression), 361, 677
Pxl-Change(, 237, 677
Pxl-Off(, 237, 677
Pxl-On(, 237, 677
pxl-Test(, 238, 678

—Q—

QuadReg (quadratic regression), 359, 678
QuartReg (quartic regression), 360, 678
Quick Zoom, 136
Quit, 619, 645

quitting CBL/CBR, 480

—R—

r (correlation coefficient), 354
r (radian notation), 99, 692
R>Pr(, **R>Pθ(** (rectangular-to-polar
 conversions), 100, 681
R², **R²** (coefficients of determination),
 354
Radian angle mode, 22, 99, 678
radian notation (**r**), 99, 692
RAM ARCHIVE ALL menu, 603
rand (random number), 92, 678
randBin((random binomial), 96, 678
randInt((random integer), 95, 679
randM((random matrix), 277, 679
randNorm((random Normal), 95, 679
random seed, 92
Ranger, 468
RCL (recall), 31, 297
re^{θi} (polar complex mode), 24, 84,
 679
Real mode, 24, 679
real((real part), 89, 679
RealTme, 476
RecallGDB, 244, 679
RecallPic, 241, 679
rectangular form, complex numbers, 86

- RectGC** (rectangular graphing coordinates), 126, 680
recursive sequences, 183
ref((row-echelon form), 280, 680
reference#, 471
RegEQ (regression equation variable), 353, 599
regression model
 automatic regression equation, 353
 automatic residual list feature, 352
 diagnostics display mode, 354
 models, 357
relational operations, 101, 272
Repeat, 517, 680
RESET MEMORY menu, 608
resetting
 all memory, 608
 archive memory, 606
 defaults, 604
 memory, 604
 RAM memory, 604
residual list (RESID), 352
Return, 523, 680
root (\sqrt{x}), 69, 693
root of a function, 148
round(, 80, 271, 680
row+(, 680
rowSwap(, 281, 680
rref((reduced-row-echelon form), 280, 681
samples (# of), 475
Scatter plot type (•), 369
Sci (scientific notation mode), 20, 683
scientific notation, 14
screen modes, 25
second cursor (2nd), 12
second key (2nd), 4
seconds DMS notation ("), 97
sector, 623
Select(, 304, 683
selecting
 data points from a plot, 305
 functions from the home screen or a program, 115
 functions in the $Y=$ editor, 115
 stat plots from the $Y=$ editor, 115
Send((send to CBL 2/CBL or CBR), 533, 683
SendID, 634
sending. *See* transmitting
SendOS, 635
Seq (sequence graphing mode), 23, 683
seq((sequence), 302, 683
sequence graphing
 axes format, 187
 CALC (calculate menu), 191
 defining and displaying, 179
 evaluating, 192

- free-moving cursor, 189
graph format, 188
graph styles, 181
moving the cursor to a value, 190
nonrecursive sequences, 182
phase plots, 197
recursive sequences, 183
selecting and deselecting, 181
setting sequence mode, 179
TI-83 Plus versus TI-82 table, 202
tracing, 189
web plots, 193
window variables, 185
 Y= editor, 180
ZOOM (zoom menu), 191
- Sequential** (graphing order mode), 24, 683
- service information, 759
- setting
- display contrast, 8
 - graph styles, 118
 - graph styles from a program, 120
 - modes, 20
 - modes from a program, 20
 - split-screen modes, 248
 - split-screen modes from a program, 255
 - tables from a program, 206
- SetUpEditor**, 350, 683
- shade above (\blacksquare) graph style, 117
- shade below (\square) graph style, 117
- ShadeF**(, 437, 684
- Shade χ^2** (, 436, 684
- Shade**(, 226, 684
- Shade_t**(, 435, 684
- ShadeNorm**(, 435, 684
- shading graph areas, 119, 226
- Simul** (simultaneous graphing order mode), 24, 685
- sin⁻¹**((arcsine), 63, 685
- sin**((sine), 63, 685
- sine (**sin**), 63, 685
- sine regression formula, 722
- sinh⁻¹**((hyperbolic arcsine), 496, 685
- sinh**((hyperbolic sine), 496, 685
- SinReg** (sinusoidal regression), 362, 685
- Smart Graph, 129
- solve**(, 77, 685
- Solver**, 72
- solving for variables in the equation solver, 75
- sonic, 468
- sonic probe, 468
- sonic-time graph, 468
- SortA**((sort ascending), 299, 348, 685
- SortD**((sort descending), 299, 348, 685
- split-screen modes
- G-T** (graph-table) mode, 252
 - Horiz** (horizontal) mode, 250

- setting, 248, 255
split-screen values, 231, 238, 254
square ($\sqrt{}$), 64, 694
square root ($\sqrt()$), 64, 695
STAT CALC menu, 356
STAT EDIT menu, 348
stat list editor
 attaching formulas to list names, 336
 clearing elements from lists, 333
 creating list names, 332
 detaching formulas from list names, 340
 displaying, 329
 edit-elements context, 344
 editing elements of formula-generated lists, 341
 editing list elements, 334
 entering list names, 330
 enter-names context, 346
 formula-generated list names, 338
 removing lists, 332
 restoring list names **L₁–L₆**, 333
 switching contexts, 342
 view-elements context, 344
 view-names context, 346
STAT PLOTS menu, 373
stat tests and confidence intervals
 χ^2 -Test (chi-square test), 412
1-PropZInt (one-proportion z confidence interval), 410
1-PropZTest (one-proportion z test), 402
2-PropZInt (two-proportion z confidence interval), 411
2-PropZTest (two-proportion z test), 403
2-SampFTest (two-sample F-Test), 414
2-SampTInt (two-sample t confidence interval), 408
2-SampTTest (two-sample t test), 400
2-SampZInt (two-sample z confidence interval), 407
2-SampZTest (two-sample z test), 399
ANOVA((one-way analysis of variance), 415
LinRegTTest (linear regression t test), 415
T-Test (one-sample t test), 397
TInterval (one-sample t confidence interval), 406
Z-Test (one-sample z test), 396
ZInterval (one-sample z confidence interval), 405
STAT TESTS menu, 394

statistical distribution functions. *See*
distribution functions
statistical plotting, 368
Boxplot (regular box plot), 371
defining, 373
from a program, 378
Histogram, 370
ModBoxplot (modified box plot),
370
NormProbPlot (normal probability
plot), 372
Scatter, 369
tracing, 376
turning on/off stat plots, 115, 375
viewing window, 376
xyLine, 369
statistical variables table, 365
Stats input option, 388, 390
stdDev((standard deviation), 314, 686
Stop, 523, 686
Store (\rightarrow), 29, 686
StoreGDB, 242, 686
StorePic, 239, 686
storing
graph databases (GDBs), 242
graph pictures, 239
variable values, 29
String \blacktriangleright Equ((string-to-equation
conversions), 493, 686
strings

concatenation (+), 490, 696
converting, 491
defined, 484
displaying contents, 488
entering, 484
functions in CATALOG, 489
length (**length()**), 492, 669
storing, 487
variables, 486, 487
student-*t* distribution
probability (**tcdf()**), 427, 687
probability density function (**tpdf()**),
427, 687
sub((substring), 493, 686
subroutines, 522
subtraction (-), 63, 696
sum((summation), 313, 686
system variables, 719

—T—

T (transpose matrix), 275, 693
T-Test (one-sample t test), 397, 688
TABLE SETUP screen, 205
tables
description, 209
variables, 205, 207
tan $^{-1}$ ((arctangent), 63, 686
tan((tangent), 63, 686
tangent (**tan()**), 63, 686

- tangent lines, drawing, 222
Tangent((draw line), 222, 687
tanh⁻¹((hyperbolic arctangent), 496, 687
tanh((hyperbolic tangent), 496, 687
TblStart (table start variable), 205
tcdf((student-*t* distribution probability), 427, 687
technical support, 758
Temperature, 468
Temp-Time, 468
TEST (relational menu), 101
TEST LOGIC (Boolean menu), 103
Text(
 instruction, 230, 254, 687
 placing on a graph, 230, 254
Then, 513, 666
thick (%) graph style, 117
TI-82
 link differences, 646
 transmitting to/from, 644
TI-83
 Link. *See* linking
TI-83 Plus
 key code diagram, 532
 keyboard, 2
 menu map, 698
TI Connect, 632
TI-GRAF LINK, 632, 633
Time axes format, 187, 687
time value of money (TVM)

I% variable (annual interest rate), 462
N variable (number of payment periods), 462
C/Y variable (number of compounding periods per year), 463
calculating, 448
formulas, 728
FV variable (future value), 462
P/Y variable (number of payment periods per year), 463
PMT variable (payment amount), 462
PV variable (present value), 462
TVM Solver, 444
tvm_N (# payment periods), 450, 688
tvm_FV (future value), 451, 688
tvm_I% (interest rate), 449, 688
tvm_Pmt (payment amount), 449, 688
tvm_PV (present value), 450, 688
variables, 462
TInterval (one-sample *t* confidence interval), 406, 687
tpdf((student-*t* distribution probability density function), 427, 687
TRACE
 cursor, 135

entering numbers during, 135, 164, 173, 189
expression display, 128, 135
Trace instruction in a program, 137, 688
transmitting
 error conditions, 652
 from a TI-73 to a TI-83 Plus, 648
 from a TI-82 to a TI-83 Plus, 646
lists to a TI-73, 642
lists to a TI-82, 641
lists to a TI-83 Plus, 648
stopping, 637
 to an additional TI-83 Plus, 638
transpose matrix (T), 275, 693
TRIGGER, 480
trigonometric functions, 63
turning on and off
 axes, 127
 calculator, 6
 coordinates, 126
 expressions, 128
 functions, 115
 grid, 127
 labels, 127
 pixels, 237
 points, 233
 stat plots, 115, 375
tvm_N (# payment periods), 450, 688
tvm_FV (future value), 451, 688

tvm_I% (interest rate), 449, 688
tvm_Pmt (payment amount), 449, 688
tvm_PV (present value), 450, 688
two-proportion z confidence interval
 (**2-PropZInt**), 411, 676
two-proportion z test (**2-PropZTest**), 403, 677
two-sample F-Test formula, 724
two-sample t test formula, 726
two-variable statistics (**2-Var Stats**), 358, 689
Type
 Bar or Meter, 469

—U—

u sequence function, 179
UnArchive, 30, 610, 689
ungrouping, 616
units, 470
user variables, 718
uv/uvAxes (axes format), 187, 689
uw/uwAxes (axes format), 187, 689

—V—

v sequence function, 179
value operation on a graph, 147
variables
 complex, 26
 displaying and storing values, 30

equation solver, 75
graph databases, 26
graph pictures, 26
independent/dependent, 209
list, 26, 286
matrix, 26, 258
real, 26
recalling values, 31
solver editor, 74
statistical, 365
string, 486, 487
test and interval output, 422
types, 26
user and system, 27, 718
VARS and Y-VARS menus, 44
variance of a list (**variance()**, 314, 689
variance((variance of a list), 314, 689
VARS menu
 GDB, 44
 Picture, 44
 Statistics, 44
 String, 44
 Table, 44
 Window, 44
 Zoom, 44
Vertical (draw line), 221, 689
viewing window, 121
Volt, 468
Voltage, 468
Volt-Time, 468

vw/uvAxes (axes format), 187, 689

—W—

w sequence function, 179
warranty information, 760
Web (axes format), 187, 689
web plots, 193
While, 516, 689
window variables
 function graphing, 121
 parametric graphing, 161
 polar graphing, 170

—X—

\sqrt{x} (root), 69, 693
XFact zoom factor, 145
x-intercept of a root, 148
xor (Boolean) exclusive or operator, 103, 690
 x^{th} root ($\sqrt[x]{\cdot}$), 69
xyLine (\triangleleft) plot type, 369

—Y—

Y-VARS menu
 Function, 45
 On/Off, 45
 Parametric, 45
 Polar, 45

Y= editor

- function graphing, 111
- parametric graphing, 158
- polar graphing, 168
- sequence graphing, 180

YFact zoom factor, 145

—Z—

Z-Test (one-sample z test), 396, 692

ZBox, 139, 690

ZDecimal, 141, 690

zero operation on a graph, 148

ZInteger, 143, 690

ZInterval (one-sample z confidence interval), 405, 690

zoom, 138, 139, 140, 141, 142, 143, 144, 145, 146

cursor, 139

factors, 145

function graphing, 138

parametric graphing, 165

polar graphing, 174

sequence graphing, 191

Zoom In (zoom in), 140, 690

ZOOM MEMORY menu, 144

ZOOM menu, 138

Zoom Out (zoom out), 140, 690

ZoomFit (zoom to fit function), 143, 691

ZoomRcl (recall stored window), 145, 691

ZoomStat (statistics zoom), 143, 691

ZoomSto (store zoom window), 144, 691

ZPrevious (use previous window), 144, 691

ZSquare (set square pixels), 142, 691

ZStandard (use standard window), 142, 691

ZTrig (trigonometric window), 142, 692

Quick-Find Locator

| | |
|--|----------|
| Chapter 1: Operating the TI-83 Plus Silver Edition..... | 1 |
| Documentation Conventions..... | 1 |
| TI-83 Plus Keyboard | 2 |
| Keyboard Zones..... | 2 |
| Using the Color-Coded Keyboard..... | 4 |
| Using the [2nd] and [ALPHA] Keys | 4 |
| Turning On and Turning Off the TI-83 Plus | 6 |
| Turning On the Calculator..... | 6 |
| Turning Off the Calculator..... | 7 |
| Batteries..... | 7 |
| Setting the Display Contrast | 8 |
| Adjusting the Display Contrast..... | 8 |
| When to Replace Batteries | 9 |
| The Display | 10 |
| Types of Displays..... | 10 |
| Home Screen | 10 |
| Displaying Entries and Answers | 10 |
| Returning to the Home Screen | 11 |
| Busy Indicator | 11 |
| Display Cursors..... | 12 |
| Entering Expressions and Instructions..... | 13 |
| What Is an Expression? | 13 |
| Entering an Expression..... | 13 |
| Multiple Entries on a Line..... | 14 |

| | |
|--|----|
| Entering a Number in Scientific Notation | 14 |
| Functions | 15 |
| Instructions..... | 16 |
| Interrupting a Calculation | 16 |
| TI-83 Plus Edit Keys | 17 |
| Setting Modes | 19 |
| Checking Mode Settings | 19 |
| Changing Mode Settings..... | 20 |
| Setting a Mode from a Program..... | 20 |
| Normal, Sci, Eng | 20 |
| Float, 0123456789 | 21 |
| Radian, Degree | 22 |
| Func, Par, Pol, Seq..... | 23 |
| Connected, Dot | 23 |
| Sequential, Simul | 24 |
| Real, $a+bi$, $re^{\theta i}$ | 24 |
| Full, Horiz, G-T..... | 25 |
| Using TI-83 Plus Variable Names..... | 26 |
| Variables and Defined Items..... | 26 |
| Notes about Variables..... | 27 |
| Storing Variable Values | 29 |
| Storing Values in a Variable..... | 29 |
| Displaying a Variable Value | 30 |
| Archiving Variables (Archive, Unarchive)..... | 30 |
| Recalling Variable Values | 31 |
| Using Recall (RCL) | 31 |
| ENTRY (Last Entry) Storage Area..... | 33 |
| Using ENTRY (Last Entry) | 33 |

| | |
|--|-----------|
| Accessing a Previous Entry | 34 |
| Reexecuting the Previous Entry..... | 34 |
| Multiple Entry Values on a Line | 35 |
| Clearing ENTRY | 36 |
| Using Ans in an Expression | 36 |
| Continuing an Expression | 37 |
| Storing Answers..... | 38 |
| TI-83 Plus Menus..... | 39 |
| Using a TI-83 Plus Menu | 39 |
| Displaying a Menu | 40 |
| Moving from One Menu to Another..... | 41 |
| Scrolling a Menu | 41 |
| Selecting an Item from a Menu | 41 |
| Leaving a Menu without Making a Selection..... | 43 |
| VARS and VARS Y-VARS Menus | 44 |
| VARS Menu | 44 |
| Selecting a Variable from the VARS Menu or VARS Y-VARS Menu | 45 |
| Equation Operating System (EOS)..... | 47 |
| Order of Evaluation | 47 |
| Implied Multiplication..... | 48 |
| Parentheses..... | 48 |
| Negation..... | 49 |
| Special Features of the TI-83 Plus | 50 |
| Flash – Electronic Upgradability | 50 |
| 1.56 Megabytes (M) of Available Memory | 50 |
| Applications..... | 51 |
| Archiving | 51 |

| | |
|---|-----------|
| Calculator-Based Laboratory™ (CBL 2™, CBL™) and Calculator-Based Ranger™ (CBR™)..... | 52 |
| Other TI-83 Plus Features | 53 |
| Graphing | 53 |
| Sequences | 53 |
| Tables | 54 |
| Split Screen..... | 54 |
| Matrices | 54 |
| Lists..... | 55 |
| Statistics..... | 55 |
| Inferential Statistics..... | 55 |
| Applications..... | 56 |
| CATALOG | 56 |
| Programming | 57 |
| Archiving | 57 |
| Communication Link | 57 |
| Error Conditions | 59 |
| Diagnosing an Error | 59 |
| Correcting an Error | 60 |
| Chapter 2: Math, Angle, and Test Operations..... | 61 |
| Getting Started: Coin Flip | 61 |
| Keyboard Math Operations | 63 |
| Using Lists with Math Operations | 63 |
| + (Addition), - (Subtraction), * (Multiplication), / (Division) | 63 |
| Trigonometric Functions | 63 |
| [^] (Power), ² (Square), $\sqrt[3]{}$ (Square Root) | 64 |
| ⁻¹ (Inverse)..... | 64 |

| | |
|---|----|
| log(, 10^(, ln(..... | 65 |
| e^((Exponential) | 65 |
| e (Constant) | 65 |
| - (Negation) | 66 |
| π (Pi) | 66 |
| MATH Operations | 67 |
| MATH Menu..... | 67 |
| ►Frac, ►Dec..... | 67 |
| $3(\text{Cube})$, $\sqrt[3]{}$ (Cube Root) | 68 |
| \sqrt{x} (Root)..... | 69 |
| fMin(, fMax(..... | 69 |
| nDeriv(..... | 70 |
| fnInt(..... | 71 |
| Using the Equation Solver | 72 |
| Solver..... | 72 |
| Entering an Expression in the Equation Solver..... | 72 |
| Entering and Editing Variable Values | 74 |
| Solving for a Variable in the Equation Solver..... | 75 |
| Editing an Equation Stored to eqn | 77 |
| Equations with Multiple Roots | 77 |
| Further Solutions..... | 77 |
| Controlling the Solution for Solver or solve(..... | 78 |
| Using solve(on the Home Screen or from a Program | 78 |
| MATH NUM (Number) Operations..... | 79 |
| MATH NUM Menu..... | 79 |
| abs(..... | 79 |
| round(..... | 80 |
| iPart(, fPart(..... | 80 |

| | |
|--|----|
| int(..... | 81 |
| min(, max(..... | 81 |
| lcm(, gcd(..... | 82 |
| Entering and Using Complex Numbers..... | 84 |
| Complex-Number Modes | 84 |
| Entering Complex Numbers | 85 |
| Note about Radian Versus Degree Mode | 85 |
| Interpreting Complex Results..... | 86 |
| Rectangular-Complex Mode | 86 |
| Polar-Complex Mode | 87 |
| MATH CPX (Complex) Operations | 88 |
| MATH CPX Menu | 88 |
| conj(..... | 88 |
| real(..... | 89 |
| imag(..... | 89 |
| angle(..... | 90 |
| abs(..... | 90 |
| ►Rect | 91 |
| ►Polar | 91 |
| MATH PRB (Probability) Operations..... | 92 |
| MATH PRB Menu | 92 |
| rand..... | 92 |
| nPr, nCr..... | 93 |
| ! (Factorial)..... | 94 |
| randInt(..... | 95 |
| randNorm(..... | 95 |
| randBin(..... | 96 |
| ANGLE Operations | 97 |

| | |
|---------------------------------------|-----|
| ANGLE Menu | 97 |
| Entry Notation | 97 |
| ° (Degree) | 98 |
| r (Radians) | 99 |
| ►DMS | 99 |
| R►Pr(, R►Pθ(, P►Rx(, P►Ry(..... | 100 |
| TEST (Relational) Operations..... | 101 |
| TEST Menu..... | 101 |
| =, ≠, >, ≥, <, ≤..... | 101 |
| Using Tests | 102 |
| TEST LOGIC (Boolean) Operations | 103 |
| TEST LOGIC Menu..... | 103 |
| Boolean Operators..... | 103 |
| and, or, xor | 103 |
| not(..... | 104 |
| Using Boolean Operations | 104 |

Chapter 3: Function Graphing..... 105

| | |
|---|-----|
| Getting Started: Graphing a Circle..... | 105 |
| Defining Graphs | 107 |
| TI-83 Plus—Graphing Mode Similarities | 107 |
| Defining a Graph..... | 107 |
| Displaying and Exploring a Graph | 108 |
| Saving a Graph for Later Use | 108 |
| Setting the Graph Modes | 109 |
| Checking and Changing the Graphing Mode | 109 |
| Setting Modes from a Program | 110 |
| Defining Functions | 111 |

| | |
|--|-----|
| Displaying Functions in the Y= Editor | 111 |
| Defining or Editing a Function..... | 111 |
| Defining a Function from the Home Screen or a Program..... | 112 |
| Evaluating Y= Functions in Expressions..... | 113 |
| Selecting and Deselecting Functions..... | 114 |
| Selecting and Deselecting a Function..... | 114 |
| Turning On or Turning Off a Stat Plot in the Y= Editor..... | 115 |
| Selecting and Deselecting Functions from the Home Screen or a Program | 115 |
| Setting Graph Styles for Functions | 117 |
| Graph Style Icons in the Y= Editor..... | 117 |
| Setting the Graph Style..... | 118 |
| Shading Above and Below..... | 119 |
| Setting a Graph Style from a Program..... | 120 |
| Setting the Viewing Window Variables | 121 |
| The TI-83 Plus Viewing Window | 121 |
| Displaying the Window Variables..... | 121 |
| Changing a Window Variable Value | 122 |
| Storing to a Window Variable from the Home Screen or a Program | 123 |
| ΔX and ΔY | 124 |
| Setting the Graph Format | 125 |
| Displaying the Format Settings | 125 |
| Changing a Format Setting | 125 |
| RectGC, PolarGC | 126 |
| CoordOn, CoordOff..... | 126 |
| GridOff, GridOn..... | 127 |
| AxesOn, AxesOff | 127 |

| | |
|--|-----|
| LabelOff, LabelOn..... | 127 |
| ExprOn, ExprOff..... | 128 |
| Displaying Graphs | 129 |
| Displaying a New Graph | 129 |
| Pausing or Stopping a Graph..... | 129 |
| Smart Graph | 129 |
| Overlaying Functions on a Graph | 130 |
| Graphing a Family of Curves | 131 |
| Exploring Graphs with the Free-Moving Cursor..... | 132 |
| Free-Moving Cursor | 132 |
| Graphing Accuracy | 132 |
| Exploring Graphs with TRACE..... | 134 |
| Beginning a Trace..... | 134 |
| Moving the Trace Cursor | 134 |
| Moving the Trace Cursor from Function to Function..... | 135 |
| Moving the Trace Cursor to Any Valid X Value..... | 135 |
| Panning to the Left or Right | 136 |
| Quick Zoom..... | 136 |
| Leaving and Returning to TRACE..... | 137 |
| Using TRACE in a Program | 137 |
| Exploring Graphs with the ZOOM Instructions..... | 138 |
| ZOOM Menu | 138 |
| Zoom Cursor | 139 |
| ZBox..... | 139 |
| Zoom In, Zoom Out..... | 140 |
| ZDecimal..... | 141 |
| ZSquare | 142 |
| ZStandard | 142 |

| | |
|---|------------|
| ZTrig..... | 142 |
| ZInteger..... | 143 |
| ZoomStat | 143 |
| ZoomFit..... | 143 |
| Using ZOOM MEMORY | 144 |
| ZOOM MEMORY Menu | 144 |
| ZPrevious..... | 144 |
| ZoomSto | 144 |
| ZoomRcl..... | 145 |
| ZOOM FACTORS | 145 |
| Checking XFact and YFact | 145 |
| Changing XFact and YFact..... | 146 |
| Using ZOOM MEMORY Menu Items from the Home Screen or a Program | 146 |
| Using the CALC (Calculate) Operations | 147 |
| CALCULATE Menu..... | 147 |
| value | 147 |
| zero | 148 |
| minimum, maximum..... | 150 |
| intersect | 151 |
| dy/dx | 152 |
| ∫f(x)dx | 153 |
| Chapter 4: Parametric Graphing | 154 |
| Getting Started: Path of a Ball | 154 |
| Defining and Displaying Parametric Graphs | 158 |
| TI-83 Plus Graphing Mode Similarities | 158 |
| Setting Parametric Graphing Mode..... | 158 |

| | |
|--|------------|
| Displaying the Parametric Y= Editor | 158 |
| Selecting a Graph Style | 159 |
| Defining and Editing Parametric Equations | 159 |
| Selecting and Deselecting Parametric Equations | 160 |
| Setting Window Variables | 160 |
| Setting the Graph Format | 161 |
| Displaying a Graph | 161 |
| Window Variables and Y-VARS Menus | 161 |
| Exploring Parametric Graphs..... | 163 |
| Free-Moving Cursor | 163 |
| TRACE | 163 |
| Moving the Trace Cursor to Any Valid T Value..... | 164 |
| ZOOM | 165 |
| CALC | 165 |
| Chapter 5: Polar Graphing | 166 |
| Getting Started: Polar Rose | 166 |
| Defining and Displaying Polar Graphs | 168 |
| TI-83 Plus Graphing Mode Similarities | 168 |
| Setting Polar Graphing Mode..... | 168 |
| Displaying the Polar Y= Editor | 168 |
| Selecting Graph Styles | 169 |
| Defining and Editing Polar Equations | 169 |
| Selecting and Deselecting Polar Equations | 169 |
| Setting Window Variables | 170 |
| Setting the Graph Format | 171 |
| Displaying a Graph | 171 |
| Window Variables and Y-VARS Menus | 171 |

| | |
|---|------------|
| Exploring Polar Graphs..... | 173 |
| Free-Moving Cursor | 173 |
| TRACE..... | 173 |
| Moving the Trace Cursor to Any Valid θ Value | 174 |
| ZOOM | 174 |
| CALC | 175 |
| Chapter 6: Sequence Graphing..... | 176 |
| Getting Started: Forest and Trees | 176 |
| Defining and Displaying Sequence Graphs | 179 |
| TI-83 Plus Graphing Mode Similarities | 179 |
| Setting Sequence Graphing Mode..... | 179 |
| TI-83 Plus Sequence Functions u, v, and w | 179 |
| Displaying the Sequence Y= Editor | 180 |
| Selecting Graph Styles | 181 |
| Selecting and Deselecting Sequence Functions..... | 181 |
| Defining and Editing a Sequence Function..... | 182 |
| Nonrecursive Sequences..... | 182 |
| Recursive Sequences | 183 |
| Setting Window Variables | 185 |
| Selecting Axes Combinations | 187 |
| Setting the Graph Format | 187 |
| Setting Axes Format | 187 |
| Displaying a Sequence Graph | 188 |
| Exploring Sequence Graphs | 189 |
| Free-Moving Cursor | 189 |
| TRACE..... | 189 |
| Moving the Trace Cursor to Any Valid n Value | 190 |

| | |
|--|------------|
| ZOOM | 191 |
| CALC | 191 |
| Evaluating u, v, and w | 192 |
| Graphing Web Plots..... | 193 |
| Graphing a Web Plot..... | 193 |
| Valid Functions for Web Plots..... | 193 |
| Displaying the Graph Screen | 194 |
| Drawing the Web | 194 |
| Using Web Plots to Illustrate Convergence | 195 |
| Example: Convergence..... | 195 |
| Graphing Phase Plots | 197 |
| Graphing with uv, vw, and uw | 197 |
| Example: Predator-Prey Model..... | 197 |
| Comparing TI-83 Plus and TI-82 Sequence Variables | 201 |
| Sequences and Window Variables | 201 |
| Keystroke Differences Between TI-83 Plus and TI-82 | 202 |
| Sequence Keystroke Changes | 202 |
| Chapter 7: Tables..... | 203 |
| Getting Started: Roots of a Function | 203 |
| Setting Up the Table | 205 |
| TABLE SETUP Screen | 205 |
| TblStart, Δ Tbl..... | 205 |
| Indpnt: Auto, Indpnt: Ask, Depend: Auto, Depend: Ask | 206 |
| Setting Up the Table from the Home Screen or a Program | 206 |
| Defining the Dependent Variables | 207 |
| Defining Dependent Variables from the Y= Editor | 207 |
| Editing Dependent Variables from the Table Editor | 207 |

| | |
|--|------------|
| Displaying the Table | 209 |
| The Table..... | 209 |
| Independent and Dependent Variables | 209 |
| Clearing the Table from the Home Screen or a Program | 210 |
| Scrolling Independent-Variable Values..... | 210 |
| Displaying Other Dependent Variables | 211 |
| Chapter 8: Draw Instructions..... | 212 |
| Getting Started: Drawing a Tangent Line | 212 |
| Using the DRAW Menu..... | 214 |
| DRAW Menu | 214 |
| Before Drawing on a Graph | 215 |
| Drawing on a Graph..... | 215 |
| Clearing Drawings | 217 |
| Clearing Drawings When a Graph Is Displayed..... | 217 |
| Clearing Drawings from the Home Screen or a Program | 217 |
| Drawing Line Segments..... | 218 |
| Drawing a Line Segment Directly on a Graph..... | 218 |
| Drawing a Line Segment from the Home Screen or a Program | 219 |
| Drawing Horizontal and Vertical Lines | 220 |
| Drawing a Line Directly on a Graph | 220 |
| Drawing a Line from the Home Screen or a Program..... | 221 |
| Drawing Tangent Lines | 222 |
| Drawing a Tangent Line Directly on a Graph | 222 |
| Drawing a Tangent Line from the Home Screen or a Program..... | 223 |
| Drawing Functions and Inverses | 224 |
| Drawing a Function | 224 |
| Drawing an Inverse of a Function | 224 |

| | |
|---|-----|
| Shading Areas on a Graph | 226 |
| Shading a Graph..... | 226 |
| Drawing Circles..... | 228 |
| Drawing a Circle Directly on a Graph..... | 228 |
| Drawing a Circle from the Home Screen or a Program | 229 |
| Placing Text on a Graph | 230 |
| Placing Text Directly on a Graph | 230 |
| Placing Text on a Graph from the Home Screen or a Program | 230 |
| Split Screen..... | 231 |
| Using Pen to Draw on a Graph | 232 |
| Using Pen to Draw on a Graph..... | 232 |
| Drawing Points on a Graph..... | 233 |
| DRAW POINTS Menu..... | 233 |
| Drawing Points Directly on a Graph with Pt-On(..... | 233 |
| Erasing Points with PtOff(..... | 234 |
| Changing Points with PtChange(..... | 235 |
| Drawing Points from the Home Screen or a Program..... | 235 |
| Drawing Pixels | 237 |
| TI-83 Plus Pixels | 237 |
| Turning On and Off Pixels with Pxl-On(and Pxl-Off(..... | 237 |
| Using pxl-Test(..... | 238 |
| Split Screen..... | 238 |
| Storing Graph Pictures (Pic) | 239 |
| DRAW STO Menu..... | 239 |
| Storing a Graph Picture | 239 |
| Recalling Graph Pictures (Pic)..... | 241 |
| Recalling a Graph Picture | 241 |
| Deleting a Graph Picture..... | 241 |

| | |
|--|------------|
| Storing Graph Databases (GDB) | 242 |
| What Is a Graph Database? | 242 |
| Storing a Graph Database | 242 |
| Recalling Graph Databases (GDB)..... | 244 |
| Recalling a Graph Database..... | 244 |
| Deleting a Graph Database | 245 |
| Chapter 9: Split Screen | 246 |
| Getting Started: Exploring the Unit Circle | 246 |
| Using Split Screen | 248 |
| Setting a Split-Screen Mode | 248 |
| Horiz (Horizontal) Split Screen..... | 250 |
| Horiz Mode..... | 250 |
| Moving from Half to Half in Horiz Mode | 251 |
| Full Screens in Horiz Mode | 251 |
| G-T (Graph-Table) Split Screen..... | 252 |
| G-T Mode..... | 252 |
| Moving from Half to Half in G-T Mode | 252 |
| Using <code>TRACE</code> in G-T Mode | 253 |
| Full Screens in G-T Mode | 253 |
| TI-83 Plus Pixels in Horiz and G-T Modes..... | 254 |
| TI-83 Plus Pixels in Horiz and G-T Modes..... | 254 |
| DRAW POINTS Menu Pixel Instructions | 254 |
| DRAW Menu Text(Instruction | 254 |
| PRGM I/O Menu Output(Instruction | 255 |
| Setting a Split-Screen Mode from the Home Screen or a Program | 255 |

| | |
|--|------------|
| Chapter 10: Matrices | 256 |
| Getting Started: Systems of Linear Equations | 256 |
| Defining a Matrix | 258 |
| What Is a Matrix? | 258 |
| Selecting a Matrix | 258 |
| Accepting or Changing Matrix Dimensions | 259 |
| Viewing and Editing Matrix Elements..... | 260 |
| Displaying Matrix Elements..... | 260 |
| Deleting a Matrix | 261 |
| Viewing a Matrix..... | 261 |
| Viewing-Context Keys | 262 |
| Editing a Matrix Element | 262 |
| Editing-Context Keys | 264 |
| Using Matrices with Expressions | 265 |
| Using a Matrix in an Expression | 265 |
| Entering a Matrix in an Expression | 265 |
| Displaying and Copying Matrices..... | 267 |
| Displaying a Matrix..... | 267 |
| Copying One Matrix to Another..... | 267 |
| Accessing a Matrix Element..... | 268 |
| Using Math Functions with Matrices | 269 |
| Using Math Functions with Matrices | 269 |
| + (Add), - (Subtract), * (Multiply) | 269 |
| - (Negation) | 270 |
| abs(..... | 271 |
| round(..... | 271 |
| -1 (Inverse)..... | 271 |

| | |
|---|------------|
| Powers | 272 |
| Relational Operations | 272 |
| iPart(, fPart(, int(..... | 273 |
| Using the MATRIX MATH Operations | 274 |
| MATRIX MATH Menu | 274 |
| det(..... | 275 |
| T (Transpose) | 275 |
| Accessing Matrix Dimensions with dim(.. | 275 |
| Creating a Matrix with dim(..... | 276 |
| Redimensioning a Matrix with dim(..... | 276 |
| Fill(..... | 276 |
| identity(..... | 277 |
| randM(.. | 277 |
| augment(.. | 277 |
| Matr►list(.. | 278 |
| List►matr(.. | 279 |
| cumSum(.. | 279 |
| Row Operations | 280 |
| ref(, rref(.. | 280 |
| rowSwap(.. | 281 |
| row+(.. | 281 |
| *row(.. | 282 |
| *row+(.. | 282 |
| Chapter 11: Lists..... | 283 |
| Getting Started: Generating a Sequence | 283 |
| Naming Lists | 286 |
| Using TI-83 Plus List Names L1 through L6 | 286 |

| | |
|---|-----|
| Creating a List Name on the Home Screen | 286 |
| Storing and Displaying Lists..... | 288 |
| Storing Elements to a List..... | 288 |
| Displaying a List on the Home Screen..... | 288 |
| Copying One List to Another..... | 289 |
| Accessing a List Element..... | 289 |
| Deleting a List from Memory..... | 289 |
| Using Lists in Graphing..... | 290 |
| Entering List Names | 291 |
| Using the LIST NAMES Menu | 291 |
| Entering a User-Created List Name Directly..... | 292 |
| Attaching Formulas to List Names | 293 |
| Attaching a Formula to a List Name..... | 293 |
| Attaching a Formula to a List on the Home Screen or in a Program | 294 |
| Detaching a Formula from a List..... | 296 |
| Using Lists in Expressions | 297 |
| Using a List in an Expression..... | 297 |
| Using Lists with Math Functions | 298 |
| LIST OPS Menu..... | 299 |
| LIST OPS Menu..... | 299 |
| SortA(, SortD(..... | 299 |
| Using dim(to Find List Dimensions | 301 |
| Using dim(to Create a List | 301 |
| Using dim(to Redimension a List | 301 |
| Fill(..... | 302 |
| seq(..... | 302 |
| cumSum(..... | 303 |

| | |
|--|------------|
| ΔList(..... | 303 |
| Select(..... | 304 |
| Before Using Select(..... | 304 |
| Using Select(to Select Data Points from a Plot..... | 305 |
| augment(..... | 307 |
| List►matr(..... | 308 |
| Matr►list(..... | 308 |
| LIST MATH Menu | 311 |
| LIST MATH Menu | 311 |
| min(, max(..... | 311 |
| mean(, median(..... | 312 |
| sum(, prod(..... | 313 |
| Sums and Products of Numeric Sequences | 313 |
| stdDev(, variance(..... | 314 |
| Chapter 12: Statistics | 315 |
| Getting Started: Pendulum Lengths and Periods..... | 315 |
| Setting Up Statistical Analyses | 328 |
| Using Lists to Store Data | 328 |
| Setting Up a Statistical Analysis | 328 |
| Displaying the Stat List Editor | 329 |
| Using the Stat List Editor | 330 |
| Entering a List Name in the Stat List Editor | 330 |
| Creating a Name in the Stat List Editor..... | 332 |
| Removing a List from the Stat List Editor..... | 332 |
| Removing All Lists and Restoring L1 through L6..... | 333 |
| Clearing All Elements from a List..... | 333 |
| Editing a List Element | 334 |

| | |
|--|-----|
| Attaching Formulas to List Names | 336 |
| Attaching a Formula to a List Name in Stat List Editor | 336 |
| Using the Stat List Editor When Formula-Generated Lists Are Displayed | 338 |
| Handling Errors Resulting from Attached Formulas..... | 339 |
| Detaching Formulas from List Names | 340 |
| Detaching a Formula from a List Name | 340 |
| Editing an Element of a Formula-Generated List..... | 341 |
| Switching Stat List Editor Contexts | 342 |
| Stat List Editor Contexts | 342 |
| Stat List Editor Contexts | 344 |
| View-Elements Context..... | 344 |
| Edit-Elements Context | 344 |
| View-Names Context | 346 |
| Enter-Name Context | 346 |
| STAT EDIT Menu | 348 |
| STAT EDIT Menu..... | 348 |
| SortA(, SortD(..... | 348 |
| ClrList..... | 349 |
| SetUpEditor..... | 350 |
| Restoring L1 through L6 to the Stat List Editor | 351 |
| Regression Model Features..... | 352 |
| Regression Model Features..... | 352 |
| Automatic Residual List | 352 |
| Automatic Regression Equation..... | 353 |
| Diagnostics Display Mode..... | 354 |
| STAT CALC Menu | 356 |
| STAT CALC Menu | 356 |

| | |
|--|-----|
| Frequency of Occurrence for Data Points..... | 357 |
| 1-Var Stats | 357 |
| 2-Var Stats..... | 358 |
| Med-Med (ax+b) | 358 |
| LinReg (ax+b) | 359 |
| QuadReg (ax ² +bx+c)..... | 359 |
| CubicReg—(ax ³ +bx ² +cx+d) | 359 |
| QuartReg—(ax ⁴ +bx ³ +cx ² + dx+e)..... | 360 |
| LinReg—(a+bx)..... | 360 |
| LnReg—(a+b ln(x)) | 360 |
| ExpReg—(ab ^x) | 361 |
| PwrReg—(ax ^b) | 361 |
| Logistic—c/(1+a*e ^{-bx}) | 361 |
| SinReg—a sin(bx+c)+d | 362 |
| SinReg Example: Daylight Hours in Alaska for One Year | 363 |
| Statistical Variables..... | 365 |
| Q1 and Q3 | 366 |
| Statistical Analysis in a Program..... | 367 |
| Entering Stat Data..... | 367 |
| Statistical Calculations | 367 |
| Statistical Plotting..... | 368 |
| Steps for Plotting Statistical Data in Lists | 368 |
| ↳ (Scatter) | 369 |
| ↳ (xyLine) | 369 |
| ↳ (Histogram) | 370 |
| ↳ (ModBoxplot) | 370 |
| ↳ (Boxplot) | 371 |
| ↳ (NormProbPlot) | 372 |

| | |
|---|------------|
| Defining the Plots..... | 373 |
| Displaying Other Stat Plot Editors..... | 375 |
| Turning On and Turning Off Stat Plots..... | 375 |
| Defining the Viewing Window | 376 |
| Tracing a Stat Plot | 376 |
| Statistical Plotting in a Program | 378 |
| Defining a Stat Plot in a Program..... | 378 |
| Displaying a Stat Plot from a Program..... | 380 |
| Chapter 13: Inferential Statistics and Distributions | 381 |
| Getting Started: Mean Height of a Population | 381 |
| Height (in centimeters) of Each of 10 Women | 381 |
| Inferential Stat Editors | 388 |
| Displaying the Inferential Stat Editors | 388 |
| Using an Inferential Stat Editor | 388 |
| Selecting Data or Stats | 390 |
| Entering the Values for Arguments | 390 |
| Selecting an Alternative Hypothesis ($\neq < >$)..... | 391 |
| Selecting the Pooled Option | 391 |
| Selecting Calculate or Draw for a Hypothesis Test..... | 392 |
| Selecting Calculate for a Confidence Interval..... | 392 |
| Bypassing the Inferential Stat Editors | 393 |
| STAT TESTS Menu | 394 |
| STAT TESTS Menu | 394 |
| Inferential Stat Editors for the STAT TESTS Instructions | 395 |
| Z-Test | 396 |
| T-Test | 397 |
| 2-SampZTest | 399 |

| | |
|---|-----|
| 2-SampTTest | 400 |
| 1-PropZTest | 402 |
| 2-PropZTest | 403 |
| ZInterval | 405 |
| TInterval | 406 |
| 2-SampZInt | 407 |
| 2-SampTInt | 408 |
| 1-PropZInt | 410 |
| 2-PropZInt | 411 |
| χ^2 -Test | 412 |
| 2-SampFTest | 414 |
| LinRegTTest | 415 |
| ANOVA(..... | 417 |
| Inferential Statistics Input Descriptions | 419 |
| Test and Interval Output Variables | 422 |
| Distribution Functions | 424 |
| DISTR menu | 424 |
| normalpdf(..... | 425 |
| normalcdf(..... | 426 |
| invNorm(..... | 426 |
| tpdf(..... | 427 |
| tcdf(..... | 427 |
| χ^2 pdf(..... | 428 |
| χ^2 cdf(..... | 429 |
| Fpdf(..... | 429 |
| Fcdf(..... | 430 |
| binompdf | 430 |
| binomcdf(..... | 431 |

| | |
|---|------------|
| poissonpdf(..... | 432 |
| poissoncdf(..... | 432 |
| geometpdf(..... | 433 |
| geometcdf(..... | 433 |
| Distribution Shading..... | 434 |
| DISTR DRAW Menu | 434 |
| ShadeNorm(..... | 435 |
| Shade _t (..... | 435 |
| Shade χ^2 (..... | 436 |
| ShadeF(..... | 437 |
| Chapter 14: Applications | 438 |
| The Applications Menu | 438 |
| Steps for Running the Finance Application..... | 439 |
| Getting Started: Financing a Car | 440 |
| Getting Started: Computing Compound Interest..... | 442 |
| Using the TVM Solver | 444 |
| Using the TVM Solver | 444 |
| Using the Financial Functions..... | 446 |
| Entering Cash Inflows and Cash Outflows..... | 446 |
| FINANCE CALC Menu..... | 446 |
| TVM Solver | 447 |
| Calculating Time Value of Money (TVM) | 448 |
| Calculating Time Value of Money | 448 |
| tvm_Pmt..... | 449 |
| tvm_I%..... | 449 |
| tvm_PV | 450 |
| tvm_N..... | 450 |

| | |
|--|-----|
| tvm_FV..... | 451 |
| Calculating Cash Flows | 452 |
| Calculating a Cash Flow | 452 |
| npv(, irr(..... | 453 |
| Calculating Amortization | 454 |
| Calculating an Amortization Schedule | 454 |
| bal(..... | 454 |
| ΣPrn(, ΣInt(..... | 455 |
| Amortization Example: Calculating an Outstanding Loan | |
| Balance | 456 |
| Calculating Interest Conversion..... | 459 |
| Calculating an Interest Conversion | 459 |
| ►Nom(..... | 459 |
| ►Eff(..... | 459 |
| Finding Days between Dates/Defining Payment Method | 460 |
| dbd(..... | 460 |
| Defining the Payment Method..... | 461 |
| Pmt_End | 461 |
| Pmt_Bgn | 461 |
| Using the TVM Variables | 462 |
| FINANCE VARS Menu | 462 |
| N, I%, PV, PMT, FV | 462 |
| P/Y and C/Y | 463 |
| The CBL/CBR Application..... | 464 |
| Steps for Running the CBL/CBR Application | 464 |
| Selecting the CBL/CBR Application | 466 |
| Data Collection Methods and Options | 467 |

| | |
|---|------------|
| Specifying the Data Collection Method from the CBL/CBR | |
| APP Menu | 467 |
| Specifying Options for Each Data Collection Method | 468 |
| GAUGE | 468 |
| TYPE | 469 |
| MIN and MAX | 470 |
| UNITS | 470 |
| DIRECTNS (Directions) | 471 |
| Data Collection Comments and Results | 471 |
| DATA LOGGER | 473 |
| #SAMPLES | 475 |
| INTRVL (SEC) | 475 |
| UNITS | 475 |
| PLOT | 476 |
| Ymin and Ymax | 476 |
| DIRECTNS (Directions) | 476 |
| Data Collection Results | 477 |
| RANGER | 478 |
| Starting Data Collection | 479 |
| Collecting the Data | 479 |
| Stopping Data Collection | 480 |
| Chapter 15: CATALOG, Strings, Hyperbolic Functions | 481 |
| Browsing the TI-83 Plus CATALOG | 481 |
| What Is the CATALOG? | 481 |
| Selecting an Item from the CATALOG | 482 |
| Entering and Using Strings | 484 |
| What Is a String? | 484 |

| | |
|---|------------|
| Entering a String | 484 |
| Storing Strings to String Variables | 486 |
| String Variables..... | 486 |
| Storing a String to a String Variable..... | 487 |
| Displaying the Contents of a String Variable | 488 |
| String Functions and Instructions in the CATALOG..... | 489 |
| Displaying String Functions and Instructions in the CATALOG | 489 |
| + (Concatenation)..... | 490 |
| Selecting a String Function from the CATALOG..... | 490 |
| Equ▶String(..... | 491 |
| expr(..... | 491 |
| inString(..... | 492 |
| length(..... | 492 |
| String▶Equ(..... | 493 |
| sub(..... | 493 |
| Entering a Function to Graph during Program Execution | 494 |
| Hyperbolic Functions in the CATALOG | 495 |
| Hyperbolic Functions | 495 |
| sinh(, cosh(, tanh(..... | 496 |
| sinh ⁻¹ (, cosh ⁻¹ (, tanh ⁻¹ (..... | 496 |
| Chapter 16: Programming..... | 497 |
| Getting Started: Volume of a Cylinder | 497 |
| Creating and Deleting Programs | 500 |
| What Is a Program? | 500 |
| Creating a New Program | 500 |
| Managing Memory and Deleting a Program | 501 |
| Entering Command Lines and Executing Programs | 504 |

| | |
|---|-----|
| Entering a Program Command Line | 504 |
| Executing a Program | 505 |
| Breaking a Program | 506 |
| Editing Programs | 507 |
| Editing a Program | 507 |
| Inserting and Deleting Command Lines | 508 |
| Copying and Renaming Programs | 509 |
| Copying and Renaming a Program | 509 |
| Scrolling the PRGM EXEC and PRGM EDIT Menus | 510 |
| PRGM CTL (Control) Instructions | 511 |
| PRGM CTL Menu | 511 |
| Controlling Program Flow | 512 |
| If | 512 |
| If-Then | 513 |
| If-Then-Else | 514 |
| For(..... | 515 |
| While | 516 |
| Repeat | 517 |
| End | 518 |
| Pause | 518 |
| Lbl, Goto | 519 |
| IS>(..... | 520 |
| DS<(..... | 521 |
| Menu(..... | 521 |
| prgm | 522 |
| Return | 523 |
| Stop | 523 |
| DelVar | 523 |

| | |
|---|------------|
| GraphStyle(..... | 524 |
| PRGM I/O (Input/Output) Instructions..... | 525 |
| PRGM I/O Menu | 525 |
| Displaying a Graph with Input | 526 |
| Storing a Variable Value with Input..... | 527 |
| Prompt | 528 |
| Displaying the Home Screen | 528 |
| Displaying Values and Messages | 529 |
| DispGraph..... | 530 |
| DispTable..... | 530 |
| Output(..... | 530 |
| getKey..... | 531 |
| TI-83 Plus Key Code Diagram | 532 |
| ClrHome, ClrTable | 532 |
| GetCalc(..... | 533 |
| Get(, Send(..... | 533 |
| Calling Other Programs as Subroutines | 535 |
| Calling a Program from Another Program..... | 535 |
| Notes about Calling Programs | 536 |
| Running an Assembly Language Program | 537 |
| Chapter 17: Activities..... | 540 |
| The Quadratic Formula | 540 |
| Entering a Calculation..... | 540 |
| Converting to a Fraction..... | 542 |
| Displaying Complex Results | 544 |
| Box with Lid | 546 |
| Defining a Function | 546 |

| | |
|---|-----|
| Defining a Table of Values | 547 |
| Zooming In on the Table | 549 |
| Setting the Viewing Window | 551 |
| Displaying and Tracing the Graph | 553 |
| Zooming In on the Graph | 555 |
| Finding the Calculated Maximum..... | 557 |
| Comparing Test Results Using Box Plots..... | 560 |
| Problem..... | 560 |
| Procedure | 561 |
| Graphing Piecewise Functions | 564 |
| Problem..... | 564 |
| Procedure | 564 |
| Graphing Inequalities..... | 566 |
| Problem..... | 566 |
| Procedure | 566 |
| Solving a System of Nonlinear Equations..... | 568 |
| Problem..... | 568 |
| Procedure | 568 |
| Using a Program to Create the Sierpinski Triangle..... | 570 |
| Setting up the Program | 570 |
| Program | 570 |
| Graphing Cobweb Attractors | 572 |
| Problem..... | 572 |
| Procedure | 572 |
| Using a Program to Guess the Coefficients..... | 574 |
| Setting Up the Program | 574 |
| Program | 574 |
| Graphing the Unit Circle and Trigonometric Curves | 576 |

| | |
|---|------------|
| Problem..... | 576 |
| Procedure | 576 |
| Finding the Area between Curves | 578 |
| Problem..... | 578 |
| Procedure | 578 |
| Using Parametric Equations: Ferris Wheel Problem..... | 580 |
| Problem..... | 580 |
| Procedure | 581 |
| Demonstrating the Fundamental Theorem of Calculus | 584 |
| Problem 1..... | 584 |
| Procedure 1 | 584 |
| Problem 2..... | 586 |
| Procedure 2 | 586 |
| Computing Areas of Regular N-Sided Polygons..... | 588 |
| Problem..... | 588 |
| Procedure | 588 |
| Computing and Graphing Mortgage Payments | 592 |
| Problem..... | 592 |
| Procedure | 592 |
| Chapter 18: Memory and Variable Management..... | 596 |
| Checking Available Memory | 596 |
| MEMORY Menu..... | 596 |
| Displaying the MEMORY MANAGEMENT/DELETE Menu..... | 597 |
| Deleting Items from Memory..... | 599 |
| Deleting an Item..... | 599 |
| Clearing Entries and List Elements..... | 601 |
| Clear Entries | 601 |

| | |
|---|-----|
| ClrAllLists | 602 |
| Resetting the TI-83 Plus | 603 |
| RAM ARCHIVE ALL Menu..... | 603 |
| Displaying the RAM ARCHIVE ALL Menu | 604 |
| Resetting RAM Memory | 604 |
| Resetting Archive Memory | 606 |
| Resetting All Memory | 608 |
| Archiving and UnArchiving Variables..... | 610 |
| Archiving and UnArchiving Variables | 610 |
| Grouping and Ungrouping Variables | 616 |
| Grouping Variables | 616 |
| Ungrouping Variables | 619 |
| DuplicateName Menu | 619 |
| Garbage Collection | 622 |
| Garbage Collection Message..... | 622 |
| Responding to the Garbage Collection Message | 622 |
| Why Not Perform Garbage Collection Automatically Without a Message?..... | 623 |
| Why Is Garbage Collection Necessary? | 623 |
| How Unarchiving a Variable Affects the Process..... | 625 |
| If the MEMORY Screen Shows Enough Free Space..... | 626 |
| The Garbage Collection Process | 626 |
| Using the GarbageCollect Command | 627 |
| ERR:ARCHIVE FULL Message | 628 |

| | |
|--|------------|
| Chapter 19: Communication Link | 629 |
| Getting Started: Sending Variables..... | 629 |
| TI-83 Plus Silver Edition LINK..... | 632 |
| Connecting Two Calculators with a Unit-to-Unit Cable | 633 |
| Linking to the CBL/CBR System | 633 |
| Linking to a Computer | 633 |
| Selecting Items to Send..... | 634 |
| LINK SEND Menu | 634 |
| Sending the Selected Items | 636 |
| Stopping a Transmission | 637 |
| Sending to a TI-83 Plus Silver Edition or TI-83 Plus | 638 |
| Sending to a TI-83 | 640 |
| Sending Lists to a TI-82 | 641 |
| Sending to a TI-73 | 642 |
| Receiving Items | 644 |
| LINK RECEIVE Menu | 644 |
| Receiving Unit..... | 644 |
| DuplicateName Menu | 644 |
| Receiving from a TI-83 Plus Silver Edition or TI-83 Plus | 645 |
| Receiving from a TI-83..... | 646 |
| Receiving from a TI-82 — Resolved Differences | 646 |
| Receiving from a TI-82 — Unresolved Differences..... | 647 |
| Receiving from a TI-73..... | 648 |
| Backing Up RAM Memory..... | 650 |
| Memory Backup Complete..... | 651 |
| Error Conditions | 652 |
| Insufficient Memory in Receiving Unit..... | 653 |

Appendix A: Tables and Reference Information..... 654

| | |
|---|-----|
| Table of Functions and Instructions | 654 |
| TI-83 Plus Menu Map | 698 |
| Variables | 718 |
| User Variables | 718 |
| Archive Variables | 719 |
| System Variables | 719 |
| Statistics Formulas | 721 |
| Logistic..... | 721 |
| SinReg | 722 |
| ANOVA(..... | 722 |
| 2-SampFTest..... | 724 |
| 2-SampTTest | 726 |
| Financial Formulas | 728 |
| Time Value of Money | 728 |
| Amortization | 731 |
| Cash Flow | 732 |
| Interest Rate Conversions | 733 |
| Days between Dates..... | 733 |

Appendix B: General Information 735

| | |
|--|-----|
| Battery Information | 735 |
| When to Replace the Batteries | 735 |
| Effects of Replacing the Batteries | 736 |
| Battery Precautions..... | 737 |
| Replacing the Batteries..... | 737 |

| | |
|--|-----|
| In Case of Difficulty | 739 |
| Handling a Difficulty | 739 |
| Error Conditions | 742 |
| Accuracy Information | 754 |
| Computational Accuracy | 754 |
| Function Limits..... | 756 |
| Function Results | 757 |
| Support and Service Information | 758 |
| Product Support | 758 |
| Product Service..... | 759 |
| Warranty Information | 760 |
| Customers in the U.S. and Canada Only | 760 |
| Australia & New Zealand Customers only | 761 |
| All Customers Outside the U.S. and Canada..... | 763 |